Australia $1.35 New Zealand $1.60 Malaysia $4.95 IR £1.11 (inc. VAT)

PRACTICAL ELECTRONICS

MAY 1982

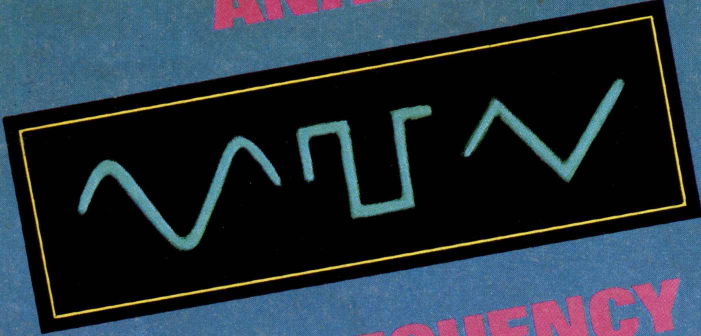
~~75p~~

1·35

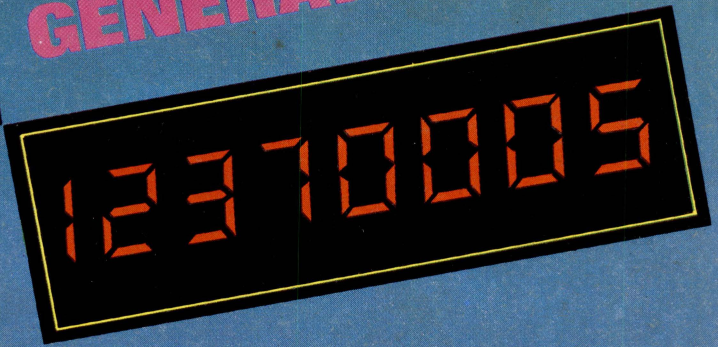
SPECIAL TEST GEAR ISSUE

Includes these exciting projects!

SIGNATURE ANALYSER

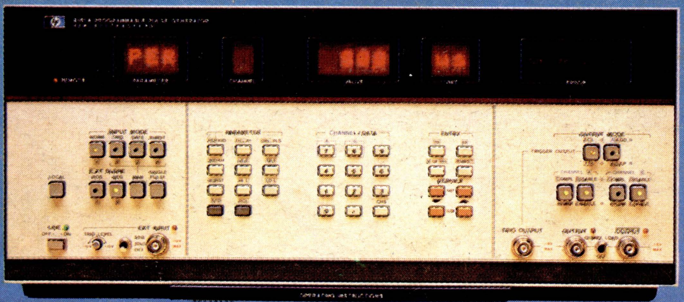


FUNCTION GENERATOR



FREQUENCY METER

Plus FREE SUPPLEMENT...



IEEE-488 IEC-625 INTERFACE BUS & AUTOMATIC TEST EQUIPMENT

PRACTICAL

ELECTRONICS

VOLUME 18 No. 5 MAY 1982

CONSTRUCTIONAL PROJECTS

GENERAL FEATURES

NEWS AND COMMENT

SPECIAL SUPPLEMENT

OUR JUNE ISSUE WILL BE ON SALE FRIDAY, MAY 14th 1982
(for details of contents see page 31)

SPEAKERS
8Ω, 0·3W, 2"; 2·25", 2·5", 3" **80p**
0·3W, 2·5" 40Ω; 64Ω or 80Ω **80p**

DIODES

AA119	**15**
BA100	**15**
BY100	**24**
BY126	**12**
BY127	**12**
CRO33	**250**
OA9	**40**
OA47	**12**
OA70	**12**
OA79	**15**
OA85	**15**
OA90	**8**
OA91	**8**
OA95	**8**
OA200	**8**
OA202	**8**
1N914	**4**
1N916	**5**
1N4001/2	**5**
1N4003	**6**
1N4004/5	**6**
1N4006/7	**7**
1N4148	**4**
1N5401	**15**
1N5404	**16**
1N5406	**17**
1N5408	**19**
1S44	**9**
1S921	**9**
6A/100V	**40**
6A/400V	**50**
6A/800V	**65**

Noise Diode
Z5J **195**

BRIDGE RECTIFIERS
(plastic case)

1A/50V	**20**
1A/100V	**22**
1A/400V	**29**
1A/600V	**34**
2A/50V	**35**
2A/200V	**40**
2A/400V	**46**
2A/600V	**65**
6A/100V	**83**
6A/400V	**95**
6A/600V	**125**
10A/200V	**215**
10A/600V	**350**
25A/200V	**240**
25A/600V	**395**
BY164	**56**
VM18	**50**

ZENERS
Range: 2V7 to 39V 400mW **8p each**
Range: 3V3 to 33V. 1·3W **15p each**

VARICAPS

MVAM2	**165**
MVAM115	**158**
BA102	**30**
BB105B	**40**
BB106	**40**

SCR's Thyristors

0·8A-100V	**32**
5A/300V	**38**
5A/400V	**40**
5A/600V	**48**
8A/300V	**60**
8A/600V	**95**
12A/100V	**78**
12A/400V	**95**
12A/800V	**188**
BT106	**150**
BT116	**180**
C106D	**38**
TIC44	**24**
TIC45	**29**
TIC47	**35**
2N5062	**32**
2N5064	**38**
2N4444	**130**

TRIACS

3A/100V	**48**
3A/400V	**56**
3A/800V	**85**
8A/100V	**60**
8A/400V	**69**
8A/800V	**115**
12A/100V	**78**
12A/400V	**82**
12A/800V	**135**
16A/100V	**103**
16A/400V	**105**
16A/800V	**220**
25A/400V	**185**
25A/800V	**295**
25A/1000V	**480**
30A/400V	**525**
T2800D	**120**

DIAC
ST2 **25**

SOLDERCON PINS
100 **70p**
500 **325p**

OPTO ELECTRONICS
LEDS including Clips

TIL209 Red 3mm	**13**
TIL211 Green 3mm	**18**
TIL212 Yellow	**18**
TIL220 ·2" Red	**15**
0·2" Yel, Grn, Amber	**18**
Rectangular LEDs with two part clip. R, G & Y	**29**
Stackable LEDs	**18**
Triangular LEDs R&G	**18**
0·2" Flashing LED Red	**55**
0·2" Bi colour LEDs Red/Green	**65**
Green/Yellow	**80**
0·2" Tri colour LEDs Red/Green/Yellow	**85**
0·2" Red High Bright	**59**
LD271 Infra Red (emit)	**46**
TIL32 Infra Red (emit)	**52**
SFH205 (detector)	**91**
TIL78 (detector)	**54**
TIL38	**45**
TIL81	**82**
TIL100	**90**

7 Segment Displays

TIL321 ·5" C.An	**115**
TIL322 ·5" C.th	**115**
DL704 ·3" C.Cth	**99**
DL707 ·3" C.Anod	**99**
DL747 ·6" C.Cathod.	**180**
·8" Orange C.A.	**250**
FND357 or 500	**120**
·3" Green C.A.	**140**
±1·3" Red or Green	**150**
Bargraph 10 seg. Red	**225**

0·5" LIQUID CRYSTAL DISPLAYS

3½ digit	**550**
4 digit	**650**
6 digit	**750**

BPX25	**95**
IL74	**45**
ILD74	**99**
ILQ74	**185**
TIL111	**75**
TIL117	**90**
OCP71	**120**
ORP12	**78**
ORP61	**85**
2N5777	**45**
4N33	**135**

OPTO SWITCH
Reflective TIL139 **170**
Slotted similar to RS **186**

ALUM. BOXES

3x2x1"	**65**
4x2½x2"	**85**
4x2½x2½"	**103**
4x4x2½"	**120**
5x4x2	**105**
5x2½x1½"	**90**
5x2½x2½"	**130**
5x4x1½"	**99**
5x4x2½"	**120**
6x4x2"	**120**
6x4x3"	**150**
7x5x3"	**180**
8x6x3"	**210**
10x4½x3"	**240**
10x7x3"	**275**
12x5x3"	**260**
12x8x3"	**295**

FERRIC CHLORIDE
1 lb bag Anhydrous
195p + 50p p&p

DALO ETCH RESIST
Pen + Spare tip **90p**

COPPER CLAD BOARDS

	Fibre Glass Single-sided	Double-sided	SRBP 9·5"x8·5"
6"x6"	**90p**	**110p**	**95p**
6"x12"	**150p**	**195p**	

VEROBOARDS 0·1"

	Clad	Plain
2½x3¾"	**73p**	**52p**
2½x5"	**83p**	—
3¾x3¾"	**83p**	—
3¾x5"	**95p**	**79p**
3¾x17"	**325p**	**211p**
4¾x18"	**425p**	—

Pkt. of 100 pins **50p**
Spot Face Cutter **118p**
Pin Insertion Tool **162p**

'VQ' Board	**150**
'DIP' Board	**330**
Vero Strip	**144**
S100 Board	**£14**

PROTO-DECs

Veroblock	**375**
S-Dec	**350**
Eurobreadboard	**520**
Bimboard 1	**695**
Superstrip SS2	**£13**

VERO WIRING PEN and Spool **310p**
Spare Wire (Spool) **75p**; Combs **6p** ea.

SPECIAL OFFER

	1+	25+
NE555	**16p**	**14p**
2114L-3	**87p**	**80p**
2114L-2	**87p**	**80p**
2708	**175p**	**160p**
2532	**395p**	**365p**
2716	**200p**	**195p**
2732	**400p**	**375p**
4116	**80p**	**70p**
6116-150ns	**450p**	**420p**
6522	**350p**	**320p**
ORP12	**78p**	**65p**

CUSTOMER: How can Watford sell full spec devices so cheaply?
WATFORD: It's simple. By bulk buying (direct from manufacturers where possible), low overheads and smaller margins which give us an edge over our competitors.

ANTEX Soldering Irons

C15W	**410**
CX17W	**425**
CCN15W	**425**
X25W	**440**
Spare bits	**50**
Elements	**200**
Iron stands	**160**
Heat Shunt	**25**

Buy with Access
Just phone your order through, we do the rest.

GAS & SMOKE DETECTORS
TGS812 & 813 **575**
Sockets **40**

ULTRASONIC TRANSDUCERS
40KHz Transmitter & Receiver **395p/pair**

DIL SOCKETS (TEXAS)

	Low profile	Wire wrap
8 pin	**8p**	**25p**
14 pin	**10p**	**35p**
16 pin	**10p**	**42p**
18 pin	**16p**	**52p**
20 pin	**22p**	**60p**
22 pin	**25p**	**70p**
24 pin	**25p**	**70p**
28 pin	**28p**	**80p**
36 pin	—	**105p**
40 pin	**30p**	**99p**

DIL PLUGS (Headers)

14 pin	**44**
16 pin	**49**
24 pin	**88**
40 pin	**255**

RIBBON CABLE

10 way	**22**
20 way	**40**
24 way	**50**
40 way	**70**

National Digitalker
IC Kit 131 words **£39**

ZERO Insertion Force DIL Sockets
24 way **595p**; 28 way **850p**; 40 way **975p**

WATFORD'S Ultimate Monitor IC.
A 4K Monitor Chip specially designed to produce the best from your: Superboard Series I & II, Enhanced Superboard & UK101. As reviewed by Dr. A. A. Berk In Practical Electronics, June 1981.
Price only £15.95 + 50p P&P.

IDC HEADERS

(Speed-block type)	IDC Headers with Latch	Free Skts	PCB Plugs Strt. Pins	Angle Pins	Ribbon Cable Grey p/foot
2 x 5 way	**90p**	**85p**	**60p**	**65p**	**12p**
2 x 8 way	**130p**	**110p**	**70p**	**78p**	**18p**
2 x 10 way	**145p**	**125p**	**80p**	**92p**	**25p**
2 x 13 way	**175p**	**150p**	**95p**	**110p**	**35p**
2 x 17 way	**205p**	**160p**	**110p**	**135p**	**48p**
2 x 20 way	**220p**	**190p**	**125p**	**150p**	**55p**
2 x 25 way	**235p**	**200p**	**150p**	**175p**	**65p**
2 x 60 way	—	**230p**	**200p**	**220p**	**70p**

EURO CONNECTORS

		Plugs	Socket	Rt. L Plug
DIN 41618	31 way	**180p**	**195p**	—
DIN 41662	2x32 way	**295p**	**350p**	**390p**
DIN 41612	3x32 way	**388p**	**425p**	**470p**

'D' CONNECTORS mini.(Cannon type) Solder Bucket

	Plugs	Sockets	Covers plastic
9 way	**95p**	**125p**	**145p**
15 way	**135p**	**198p**	**150p**
25 way	**170p**	**230p**	**100p**
37 way	**290p**	**398p**	**185p**

PCB Pins
25 way **200p** **245p** —

PCB Pins (right angle)
25 way **210p** **275p** —

TRANSFORMERS (mains Prim. 220-240V)
6-0-6V 100mA; 9-0-9V 75mA; 12-0-12V 75mA **98p**
6VA type: 6V-·5A 6V-·5A; 9V-·4A 9V-·4A; 12V-·3A 12V-·3A; 15V-·25A 15V-·25A **220p**
12VA: 4·5-1·3A 4·5V-1·3A; 6V-1·2, 6V-1·2A 12V-·5A 12V-·5A **295p** (30p p&p)
24VA: 6V-1·5A 6V-1·5A; 9V-1·2A 9V-1·2A; 12V-1A 12V-1A; 15-·8A 15-·8A; 20V-·6A 20V-·6A **330p** (44p p&p)
50VA: 2x6V-4A; 2x9V-2·5A; 2x12V-2A; 2x15V-1·5A; 2x20V-1·2A; 2x25V-2A; 2x30V-0·8A **440p** (60p p&p)
100VA: 2x12V-4A; 2x15V-3A; 2x20V-2·5A; 2x30V-1·5A; 2x40V-1·25A; 2x50V-1A **920p** (60p p&p)

Amphenol Plugs
24 way IEEE **575p**
36 way Centronic Parallel **550p**

EDGE CONNECTORS Two rows

	·1	·156
2x10 way	—	**135p**
2x15 way	—	**140p**
2x18 way	**180p**	**145p**
2x22 way	**199p**	**200p**
2x23 way	**210p**	—
2x25 way	**225p**	**220p**
2x30 way	**245p**	—
2x36 way	**295p**	—
2x40 way	**315p**	—
2x43 way	**395p**	—
2x75 way	**550p**	—

JUMPER LEADS Ribbon Cable Assembly

Length	14pin	16pin	24 pin	40 pin
Single Ended DIP (Header) Lead				
24"	**145p**	**165p**	**240p**	**380p**
Double Ended DIP (Header) Lead				
6"	**185p**	**205p**	**300p**	**465p**
12"	**198p**	**215p**	**315p**	**490p**
24"	**210p**	**235p**	**345p**	**540p**
36"	**230p**	**250p**	**375p**	**595p**
Single Ended Socket Lead				
24"	**155p**	**210p**	**265p**	**300p**
Double Ended Socket Lead				
24"	**290p**	**385p**	**489p**	**540p**

COMPUTER CORNER

- **VIC 20 MICROCOMPUTER.** Connects directly to a colour TV. 5K RAM expandable to 32K PET type graphics. **£165**
- **CASSETTE DECK** for VIC20 including a free 6 programme Cassette. **£39**
- **EPSON MX SERIES PRINTERS:** Full range available. Please phone for prices.
- **SEIKOSHA GP100A** – Unihammer Printer, gives normal and double width characters as well as dot resolution graphics 10" Tractor feed. Parallel Interface standard. **£195**
- **SOFTY-2.** As reviewed in PE September 1981. The complete microprocessor development system for Engineers & Beginners. New powerful instruction. Accepts any 24 pin 5V single rail EPROM. Supplied fully built, tested & enclosed in a black ABS case. Price incl. encapsulated plug in power supply. **£169**
- **VIDEO MONITOR** 9" fully cased. B&W. Fully guaranteed. Excellent value for money at only **£79**
- **TEX EPROM ERASER.** Erases up to 32 ICs in 15-30 min. **£33**
- **TEX EPROM ERASER** with integral 30 min. Electronic timer **£45**
- **Spare** 'UV lamp bulbs **£9**
- **5V/5A PSU** Ready built and tested **£25**
- Attractive Beige/Brown **ABS CASE** for Superboard/UK101 or Home Brew **£26**
- **Extra 4K of RAM** (8 off 2114L-300nS) **£7**
- **Space Invaders** for Superboard **£6**
- **Full ASC11** coded keyboard type '756' **£39**
- **4 x 4 matrix keypad** (reed switch assembly) **£4**
- **C12 Cassettes** in Library Cases **40p**
- **8½ Fan fold paper** (500 sheets) (no VAT) **£6**
- **9½" Fan fold paper** (500 sheets) (no VAT) **£6**
- **Teleprinter Roll** (no VAT) **£3.50**

(P&P on most of the above items is extra)
Call in at our shop for demonstration of any of the above items. Be satisfied before you buy.

VOLTAGE REGULATORS

1A	T03 +ve		−ve	
5V	7805	**145p**	7905	**220p**
12V	7812	**145p**	7912	**220p**
15V	7815	**145p**	7915	**220p**
18V	7818	**150p**		—
1A	T0220 Plastic Casing			
5V	7805	**50p**	7905	**55p**
12V	7812	**50p**	7912	**55p**
15V	7815	**50p**	7915	**55p**
18V	7818	**50p**	7918	**55p**
24V	7824	**50p**		
100mA	T092 Plastic Casing			
5V	78L05	**30p**	79L05	**60p**
6V	78L62	**30p**		—
8V	78L82	**30p**		—
12V	78L12	**30p**	79L12	**60p**
15V	78L15	**30p**	79L15	**60p**

LM300H	**170**	LM309K	**135**
LM304H	**160**	LM317H	**280**
LM305H	**140**	LM317K	**350**
78H05 5V/5A	**550p**	LM317P	**99**
78HG+5 to +24V 5A	**599p**	LM323K	**500**
		LM326N	**240**
79HG −2.25V to −24V 5A	**785p**	LM723	**35**
		TBA625B	**75**

SWITCHES

SLIDE 250V

1A DPDT	**14**
1A DPDT C/OFF	**15**
½A DP on/on/on	**40**

TOGGLE 2A 250V

SPST	**33**
DPDT	**44**
4 pole on off	**54**

PUSH BUTTON Spring loaded

Latching or Momentary 6A	
SPDT c/over	**99**
DPDT c/over	**145**

MINIATURE Non Locking

Push to make	**15p**
Push break	**25p**

SUB-MIN TOGGLE

SP changeover	**60**
SPST on off	**54**
SPDT c/off	**85**
SPDT Biased	**105**
DPDT 6 tags	**75**
DPDT C/OFF	**88**
DPDT Biased	**145**
3 pole c/over	**205**

ROCKER: 5A, 250V, SPST **28p**
ROCKER: (white) 10A 250V SPDT **38p**
ROCKER: With neon lights red when on. 10A 250V, DPST **85p**
ROCKER: (White) 10A/250V DPDT **72p**
ROTARY: Make your own Multiway Switch. Shafting Assembly accommodates up to 6 wafers. **90p**
Break before make Wafers. Silver contacts. 1 pole/12 way; 2 pole/6 way; 3 pole/4 way; 4 pole/3 way; 6 pole/2 way **65p**
Mains DPST Switch to fit **45p**
Screen & Spacers **6p**
ROTARY: (Adjustable Stop Type) 1 pole/2 to 12 way, 2p/2 to 6 way, 3 pole/2 to 4 way, 4 pole/2 to 3 way **45p**
ROTARY: Mains 250V AC, 4 Amp **56p**

DIL SWITCHES: (SPST) 4 way **70p**; 6 way **85p**; 8 way **90p**; 10 way **145p**; (SPDT) 4 way **190p**.

CRYSTALS

32·768KHz	**100**
100KHz	**270**
200KHz	**295**
455KHz	**370**
1MHz	**295**
1·28MHz	**392**
1·6MHz	**395**
1·8MHz	**395**
1·008M	**290**
1·8432M	**220**
2·0MHz	**240**
2·4576M	**220**
3·2768M	**220**
3·57954M	**150**
3·6864M	**300**
4·0MHz	**200**
4·032MHz	**290**
4·80MHz	**200**
4·194304M	**200**
4·433619M	**120**
5·0MHz	**200**
5·185MHz	**300**
5·24288M	**390**
6·0MHz	**220**
6·144MHz	**200**
6·5536MHz	**200**
7·0MHz	**200**
7·168MHz	**250**
7·68MHz	**200**
8·0MHz	**200**
8·08333M	**395**
8·867237M	**200**
9·00MHz	**200**
9·375MHz	**350**
10·0MHz	**200**
10·7MHz	**220**
10·24MHz	**200**
12·0MHz	**290**
12·528MHz	**300**
14·31818M	**320**
16·0MHz	**250**
18·0MHz	**240**
18·432M	**240**
19·968MHz	**325**
20·0MHz	**325**
24·0MHz	**200**
24·930MHz	**325**
26·69M	**290**
26·670MHz	**325**
27·648M	**330**
27·145M	**240**
27·125MHz	**295**
38·66667M	**290**
48·0MHz	**270**
100·0MHz	**375**
116·0MHz	**300**

ASTEC UHF Modulators
6MHz **280**
8MHz Wide-bandwidth **425**

WATFORD'S UNIVERSAL MICRO EXPANSION SYSTEM

Designed by Watford Electronics, this extremely versatile and economical Expansion System as published in E.T.I., starting from Dec., 81 issue, offers a low cost flexible expansion facility for **ZX81, UK101, SUPERBOARD, ACORN ATOM, PET, TANGERINE, VIDEO GENIE, VIC 20.**
The Motherboard (Interfaces with the Computer) has capacity to accept up to five daughter cards and can be paralleled for even more daughter cards. All PCBs are of Computer grade finish and are supplied in Kit form.

Just look at the expansion possibilities:
MOTHERBOARD – Accepts up to five Daughter Cards **Full Kit: £36.50**
SOUND CARD – Utilising up to three AY-3-8910 Sound chips. (one supplied with every Kit) **Full Kit: £24.95**
PIO CARD – Using two 6520 PIA chips, this Board offers Centronics parallel printer driver, digital to analogue converter and a host of other out-put facilities. **Full Kit: £19.95**
PROM PROGRAMMER – This simple but extremely useful card can blow 2716 or 2732 single rail EPROMS. **Full Kit: £25.95**
EPROM CARD – This card houses 4x2716 or 2x2532/2732. **Full Kit: £11.80**
RAM CARD – 8K RAM card. Accepts 16x2114 RAMs. The Board is supplied fully populated. **Full Kit: £28.50**
Coming soon: Disc Interface Card, 32K Dynamic RAM Card Speech Card & High Resolution Colour Graphics Card.
(N.B. PCBs may be bought separately)

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Amplifiers
Audio leads
Audible warning devices

Batteries
- chargers
- connectors
- holders

Bezels
Books
Boxes
Bridge rectifiers
Bulbs
- holders

Busbars
Buzzers

Cable
- clips
- ties
- markers
- sleeving
- wrapping
- stripper

Capacitors
- air spaced
- trimmer
- suppression
- feed through
- ceramic
- electrolytic
- polyester
- polystyrene
- silver mica
- tantalum

Cermet pre-sets
Chokes
Coilformers
Connectors
Coils
Continuity testers
Convertors
Crimp tools
Crocodile clips
Crystals

Denco products
Demagnetisers
Desolder braid
Desolder pump
Diacs
Diodes
- light emitting
- photo
- rectifier
- signal
- zener
- germanium
- infra-red

Displays
Drills

Earpieces
Earphones
Enamelled copper wire
Etch resist products

Filters
Ferric chloride
Ferrite cores
Ferrite rods
Fixing feet
Fuses
Fuse holders
Fluorescent displays
Field strength motors
Frequency counter

Gas sensor
Gronmets
Group panels
Grease

Headphones
Heat sinks

Inspection glasses
I.C.s
I.C. sockets
Infra-red source
Infra-red sensor
Indicators
Insulating tape

Jack connectors
Jewellers screwdrivers

Keyboards
Keynector
Knobs

Lamps
Lamp holders
Leads
Liquid crystal displays
LED
LED arrays
LED displays

Mains adaptor
Matrix board
Memory I.C.s
Meters
Microphones
- inserts
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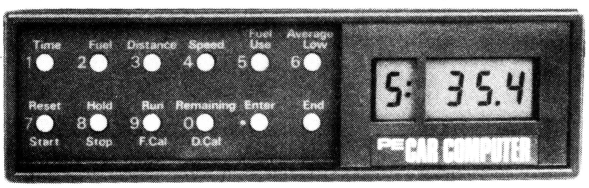
PE CAR COMPUTER



This unit was described by Practical Motorist as: "One of the neatest, most comprehensive and most useful of these car computers that we have yet come across . . ."

The PE Car Computer was designed to exceed the specification of all others, both for number of functions and accuracy. As well as the usual functions, it can perform eleven "remaining" type calculations, has a unique "start-stop" mode (used for acceleration timing and the like) and has a combination lock for driving an alarm or ignition cut-out.

The unit is housed in a custom designed box with high quality printed panels having an overall size of 165 × 50 × 80mm deep, and can be fitted above or below the dashboard. The display is liquid crystal for clarity in all lighting conditions.

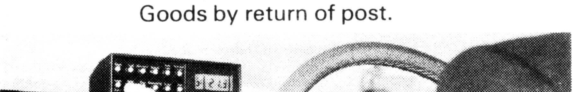
The kit includes all sensors, wiring, etc and is suitable for all cars except those fitted with diesel or fuel injection engines.

Kit price: £78.50 Assembled Price: £88.50

+ £1 p&p includes VAT.

Send S.A.E. for list of separately available parts.

Goods by return of post.



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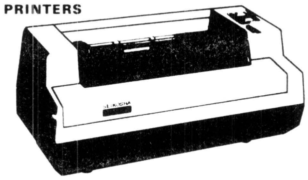
ACORN ATOM
BK rom + 2K ram built **£150.** 12K rom + 12K ram built **£198.** Extra ram **£2.10** per K. 4K rom **£25.** Power supply **£10.20.**

UK101 AND SUPERBOARD
UK101 with 1K and free power supply and modulator kit **£120,** built **£149.** UK101 display expansion kit **£14.** The below accessories suit both the UK101 and superboard:- Extra ram **£2.10** per K. 16K memory expansion complete kit **£50,** built **£58.** 32K memory expansion kit **£74,** built **£82.** Cassette recorder **£19.** Cegmon **£22.50.** Wemon **£19.95.** Word processor program **£10.** Centronics interface kit **£10.** 610 expansion board **£179.** Cased minifloppy disc drive with DOS **£275.** The below suit only superboard:- Colour adaptor board built **£45.** Assembler/Editor tape **£25.** Guard band kit **£10.** Series 1 only 30 lines × 50 characters display expansion kit.

NEW GENIE 1 £299
EG3014 Expansion box with 16K/32K ram **£199/£213.** Disk drive **£220.** Double density convertor **£72.** Ldos **£88.** Newdos+ **£49.** Ajedit disk word-processor **£44.** Colourboard **£36.** Parallel printer interface **£36.** Monitors:- EG100 white **£69,** OVM9PGR green **£99.** Colour Genie poa. Genie 3 poa.

PRINTERS



Buy any of the below and get a free interface kit and word processor program for UK101 or Superboard:- Epson MX70 **£259.** Epson MX80T **£359.** Epson MX80F/T1 **£395.** Epson MX80F/T2 **£430.** OKI Microline 80 **£295.** OKI Microline 82A **£399.** Centronics 737 **£335.** Centronics 739 **£419.** Seikosha GP80 **££199.**

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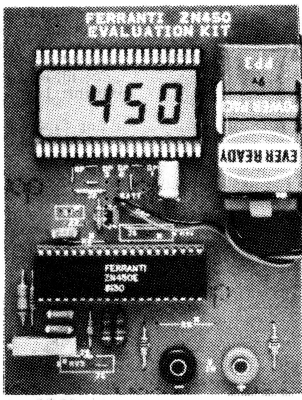

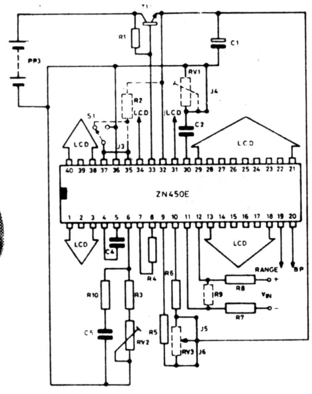

OPTIONAL COMPONENTS SHOWN DOTTED

INTRODUCTION

The ZN450 is the first charge-balancing DVM I.C. to contain all the active circuitry on a single chip and requires only a handful of external passive components and a display to function.

No engineering design effort is required and the only obstacle to building a DVM is that of obtaining the components and wiring a breadboard. The ZN450 evaluation kit is intended to remove even this obstacle and to facilitate the evaluation of this unique I.C. The kit contains all the components necessary to construct a DVM with a basic sensitivity of 199.9 mV full-scale, powered from a 9V battery (not supplied).

In addition, provision is made on the printed circuit board for various options to increase the versatility of the DVM. Components required for these options are NOT provided but suitable values are indicated in the text. Additional applications data on the ZN450 is given in the data sheet.

Price: £19.95 each ex VAT and P & P (Total £24.15)

Device	Price
MEMORIES	
2114L-200ns	1+0.93
	25+0.89
2114L-300ns GTE (FOR ACORN ATOM)	1.55
2708 450ns	1+2.25
	25+1.99
2716 450ns	1+2.49
(single +5V)	25+2.25
2716 350ns	6.95
2532 450ns	1+4.50
	25+4.25
2732 450ns	1+3.99
	25+3.80
2732 350ns	7.50
4116 200ns	1+0.74
	25+0.70
	100+0.67
4116 150ns	1+0.93
	25+0.89
4118 200ns	1+3.90
	25+3.45
4118 150ns	6.00
5516 200ns	12.50
6116 200ns	7.95
6116LP 200ns	10.00
6116LP 150ns	10.85
CRT CONTROLLERS	
EF6845P	9.50
EF9364P	5.94
EF9365P	62.90
EF9366P	62.90
EF9365/6 DATA AND APPLICATIONS	2.00
BUFFERS	
81LS95	0.90
81LS96	0.90
81LS97	0.90
81LS98	0.90
8T26A	0.99
8T28A	1.40
8T95	1.35
8T97A	1.35
8T98	1.45
DATA CONVERTERS	
ZN425E-8	3.45
ZN426E-8	3.00
ZN427E-8	5.99
ZN428E-8	4.75
ZN429E-8	2.10
ZN432CJ-10	28.09
ZN433CJ-10	2.59
ZN440	56.63
ZN432E-10	14.75
ZN447	9.14
ZN448	6.85
ZN449	3.20
NEW FLOPPY DISC CONTROLLERS	
FD1771	17.12
FD1791	32.61
FD1793	32.61
FD1795	35.33
WD1391	45.50
WD1393	45.50
WD1395	45.50
WD1397	45.50
WD2143-01	5.45
WD1691	10.87
MISCELLANEOUS SUPPORT CHIPS	
AY-3-1015	3.25
AY-3-1270	7.95
AY-3-8910	6.95
AY-5-1013	3.45
AY-5-3600	7.95
AY-5-2376	6.95
DP8304	4.50
MC1488	0.59
MC1489	0.59
MC3446	2.95
MC3448A	4.25
MC3480	7.95
MC3487	2.95
MC14411	6.94
MC14412	7.99
RO-3-2513L	6.99
RO-3-2513U	5.99
ULN2803A(L203)	0.84
DVM CHIPS	
ZN450e	7.61
ZN450E DVM KIT	25.00
NEW LINEARS	
LM301AN	0.25
LM308N	0.89
LM311N	0.69
LM319N	2.20
LM324N	0.30
LM348N	0.59

Device	Price
LM555CN	0.16
LM556CN	0.49
LM725CN	3.20
LM741CN	0.14
LM747CN	0.70
LM748CN	0.34
REGULATORS	
7805	0.39
7812	0.39
7815	0.39
78L05	0.29
78L12	0.29
78L15	0.29
7905	0.55
7912	0.55
7915	0.55
79L05	0.59
79L12	0.59
79L15	0.59
LM309K	0.99
LM317K	3.20
LM323K	4.95
LM338K	4.75
Z80 FAMILY	
Z80 CPU	3.49
Z80A CPU	3.99
Z80 CTC	2.99
Z80A CTC	2.99
Z80 DART	10.00
Z80A DART	12.00
Z80 DMA	9.95
Z80A DMA	11.95
Z80 PIO	3.49
Z80A PIO	3.75
Z80 SIO-0	10.99
Z80A SIO-0	11.99
Z80 SIO-1	10.99
Z80A SIO-1	11.99
Z80 SIO-2	10.99

Device	Price
CMOS 4000 'B' SERIES	
4000	0.11
4001	0.11
4002	0.13
4006	0.60
4007	0.15
4008	0.55
4009	0.28
4010	0.35
4011	0.12
4012	0.15
4013	0.29
4014	0.58
4015	0.58
4016	0.25
4017	0.45
4018	0.58
4019	0.29
4020	0.58
4021	0.60
4022	0.62
4023	0.17
4024	0.35
4025	0.16
4026	0.99
4027	0.30
4028	0.55
4031	1.65
4033	1.60
4034	1.55
4035	0.72
4040	0.54
4041	0.69
4042	0.54
4043	0.59
4044	0.64
4045	1.65
4046	0.68
4047	0.68
4048	0.54
4049	0.26

Device	Price
4543	0.99
4553	2.90
4555	0.39
4556	0.44
4585	0.62
74LS SERIES	
74LS00	0.10
74LS01	0.11
74LS02	0.12
74LS03	0.12
74LS04	0.12
74LS05	0.13
74LS08	0.12
74LS09	0.12
74LS10	0.12
74LS11	0.12
74LS12	0.12
74LS13	0.22
74LS14	0.39
74LS15	0.12
74LS20	0.12
74LS21	0.12
74LS22	0.12
74LS26	0.15
74LS27	0.12
74LS28	0.15
74LS30	0.12
74LS32	0.12
74LS33	0.16
74LS37	0.15
74LS38	0.15
74LS40	0.12
74LS42	0.34
74LS47	0.39
74LS48	0.60
74LS49	0.59
74LS51	0.14
74LS54	0.15
74LS55	0.15
74LS73	0.19
74LS74	0.16

Device	Price
74LS190	0.49
74LS191	0.49
74LS192	0.49
74LS193	0.46
74LS194	0.39
74LS195	0.39
74LS196	0.59
74LS197	0.65
74LS221	0.54
74LS240	0.89
74LS241	0.89
74LS242	0.79
74LS243	0.79
74LS244	0.65
74LS245	0.89
74LS247	0.63
74LS248	0.63
74LS249	0.63
74LS251	0.40
74LS253	0.39
74LS257	0.40
74LS258	0.39
74LS259	0.79
74LS261	1.95
74LS266	0.23
74LS273	0.75
74LS279	0.39
74LS283	0.44
74LS290	0.54
74LS293	0.45
74LS365	0.34
74LS366	0.36
74LS367	0.34
74LS368	0.49
74LS373	0.74
74LS374	0.74
74LS375	0.47
74LS377	0.89
74LS378	0.69
74LS379	0.64
74LS386	0.28
74LS390	0.54
74LS393	0.59
DIL SOCKETS LOW PROFILE - TIN	
8 pin	0.07
14 pin	0.09
16 pin	0.09
18 pin	0.13
20 pin	0.14
22 pin	0.17
24 pin	0.19
28 pin	0.25
40 pin	0.29
NEW LOW PROFILE - GOLD	
8 pin	0.22
14 pin	0.29
16 pin	0.31
18 pin	0.33
20 pin	0.35
22 pin	0.40
24 pin	0.42
28 pin	0.54
40 pin	0.81
NEW ZERO - INSERTION FORCE DIL	
24 pin	6.30
28 pin	7.40
40 pin	8.80
CRYSTALS	
1 MHz	2.90
1.008 MHz	2.90
1.8432 MHz	2.20
3.6864 MHz	2.95
4 MHz	1.65
6 MHz	1.90
8 MHz	1.95
14 MHz	3.45
NEW UHF MODULATORS	
6 MHz	2.75
8 MHz	4.40
DATABOOKS	
THOMSON-EFCIS 6800 Data Book (Inc p&p)	5.95
Data Converter Handbook (Inc p&p)	1.58

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MK 3886	11.00
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6800 FAMILY	
6800	2.99
6802	3.99
6803C	11.80
6809	9.99
6810	1.25
6821	1.25
6840	4.20
6850	1.50
6862	6.91
6871AIT	18.70
6880	1.07
6887	0.80
68488	9.11
6875	4.18
6843	13.99
68B00	4.70
68B02	19.11
68B21	2.29
68B10	2.00
68B40	4.70
68B50	2.15
68000C4	110.00
6500 FAMILY	
6502	4.25
6520	2.99
6522	4.75
6532	6.95
8080 FAMILY	
8085A	5.50
8212	1.70
8216	0.99
8224	1.95
8228	3.95
8251	3.60
8253	7.95
8255	3.60

Device	Price
4050	0.26
4051	0.59
4052	0.68
4053	0.59
4054	1.20
4055	1.20
4060	0.79
4063	0.95
4066	0.34
4068	0.17
4069	0.17
4070	0.17
4071	0.17
4072	0.17
4073	0.19
4075	0.17
4076	0.62
4077	0.22
4078	0.24
4081	0.14
4082	0.19
4085	0.63
4086	0.69
4093	0.39
4502	0.69
4507	0.39
4508	1.90
4510	0.60
4511	0.49
4512	0.60
4514	1.49
4515	1.49
4516	0.69
4518	0.40
4519	0.28
4520	0.69
4521	1.49
4522	1.20
4526	0.70
4527	0.89
4528	0.70
4532	0.85
4541	0.99

Device	Price
74LS75	0.24
74LS76	0.20
74LS78	0.19
74LS83	0.44
74LS85	0.65
74LS86	0.15
74LS90	0.30
74LS91	0.75
74LS92	0.34
74LS93	0.34
74LS95	0.43
74LS109	0.21
74LS112	0.21
74LS113	0.23
74LS114	0.19
74LS122	0.39
74LS123	0.39
74LS124	0.99
74LS125	0.25
74LS126	0.25
74LS132	0.45
74LS136	0.28
74LS138	0.34
74LS139	0.35
74LS145	0.75
74LS148	0.90
74LS151	0.39
74LS153	0.29
74LS155	0.39
74LS156	0.38
74LS157	0.31
74LS158	0.31
74LS160	0.39
74LS161	0.39
74LS162	0.39
74LS163	0.39
74LS164	0.47
74LS165	0.99
74LS166	0.84
74LS173	0.70
74LS174	0.47
74LS175	0.49
74LS181	1.28

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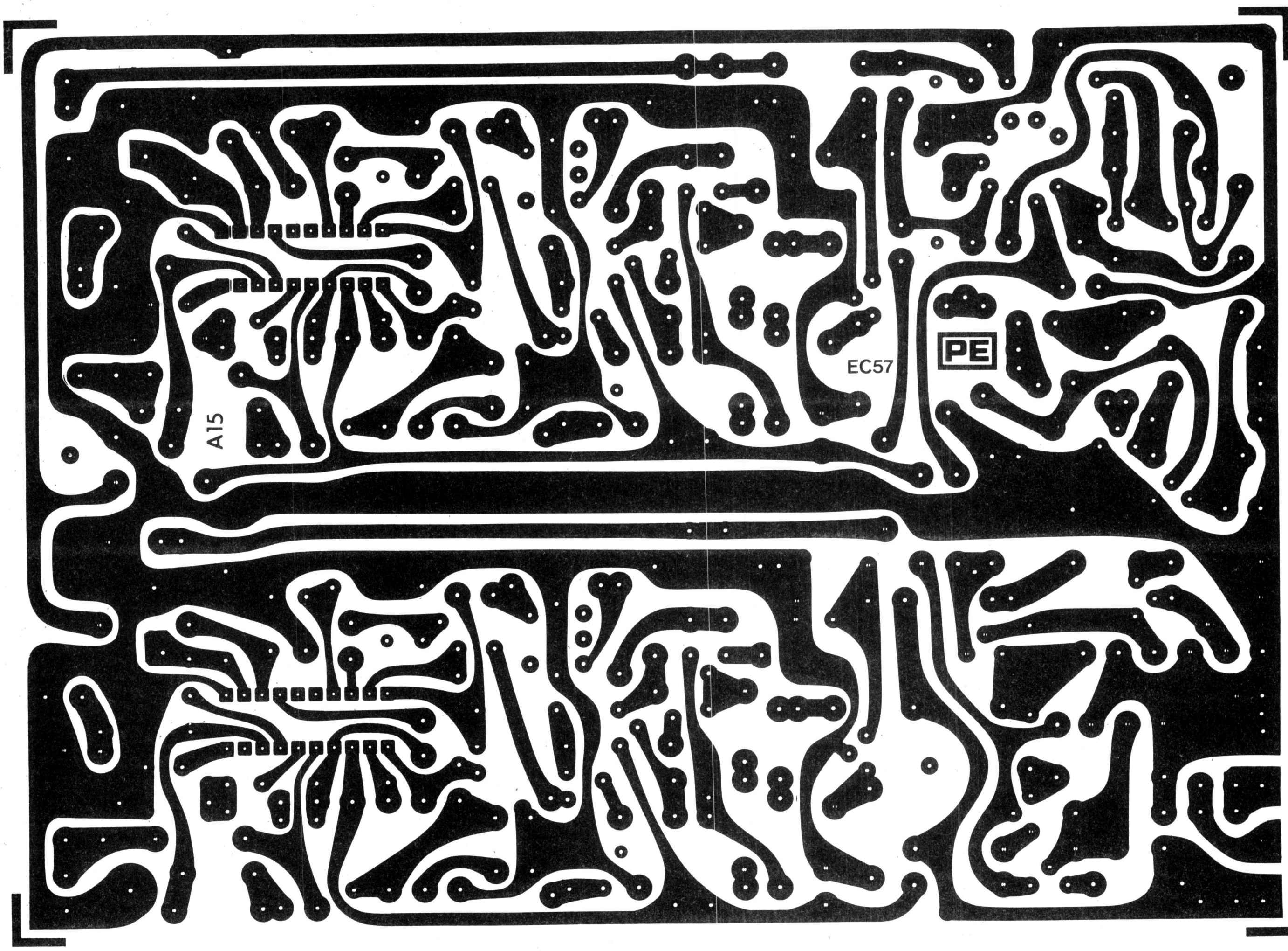


Fig. 1. P.c.b. design for the Quasar

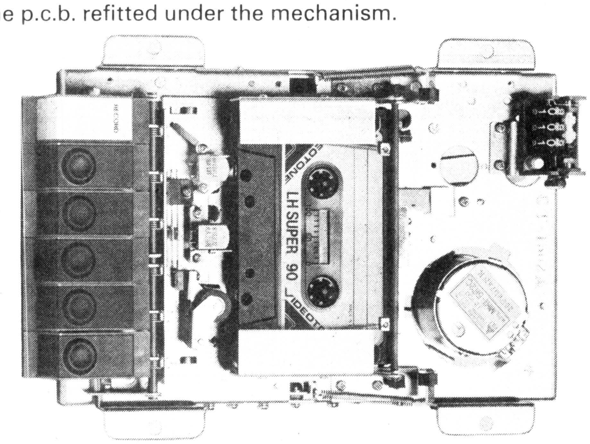
'flat' position. The background noise should drop to an almost non-existent level (depending upon your amplifier). With the switch in the HF position, only the noise with high frequency content will be affected.

The GNR system can be checked during the on/off signal condition by pressing the pause key whilst playing the pre-recorded tape. It will be found that for sustained music the 'flat' position will be best. For tapes containing mostly quiet passages the 'HF' should be used; the presets PR2 can be adjusted for balance and to suit the sensitivity of each amplifier.

RECORD

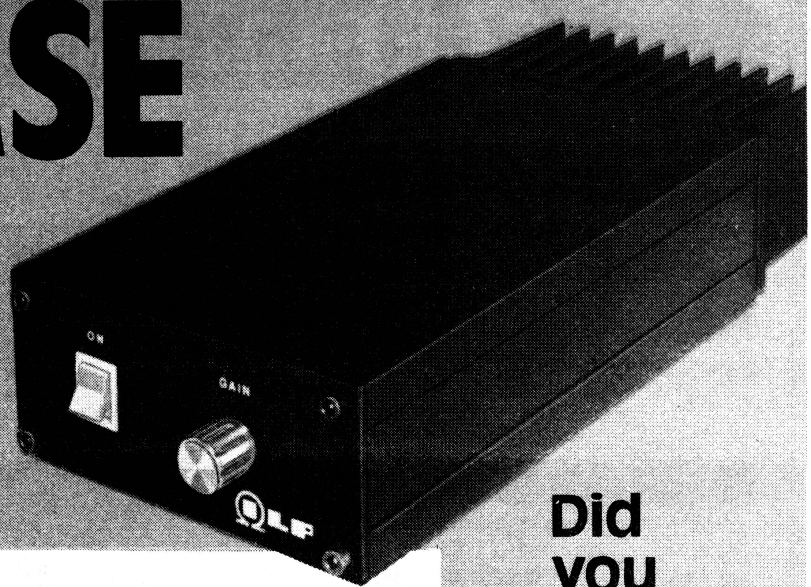
To set the Quasar up on 'record', the p.c.b. should be hinged back so that L1 is accessible. When the fixing screws are removed a temporary earth should be connected between the p.c.b. and the deck chassis otherwise hum will result. Remember this earth must be removed when the unit is reassembled.

A blank tape should be inserted into the machine (with it's rear tabs intact) and the bias level and EQ switch set to suit the tape used. A scope should then be connected between the earth and the junction of C17 and L1. Press the record button only and adjust L1 to obtain the minimum bias frequency reading. If a scope is not available then one channel can be used to monitor the other i.e. the left channel bias rejection can be monitored with the right hand VU meter and vice versa. This can be carried out by connecting the junction of C17 and L1 to the DIN input of the opposite channel. The corresponding level control should then be adjusted to obtain a reading on the meter and L1 adjusted for minimum deflection. This procedure should be carried out for the second channel and then the temporary earth removed and the p.c.b. refitted under the mechanism.

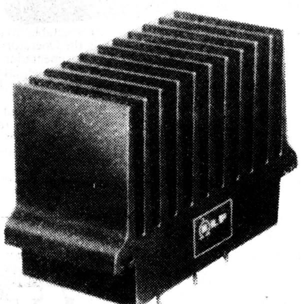


Photograph showing the top of the cassette mechanism. After the cassette mechanism has been mounted into the case and screwed into position the Perspex cover should be glued onto the two aluminium brackets mounted either side of the cassette compartment. Finally the offcut from the fascia panel legend should be trimmed and glued onto the cover.

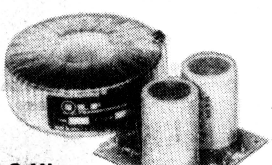
THE CASE FOR ILP



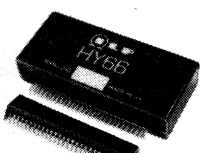
It's the chance every constructor wants



POWER AMPS



P.S.U's



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Sinclair ZX81 Personal Comp
the heart of a system that grows with you.

1980 saw a genuine breakthrough – the Sinclair ZX80, world's first complete personal computer for under £100. Not surprisingly, over 50,000 were sold.

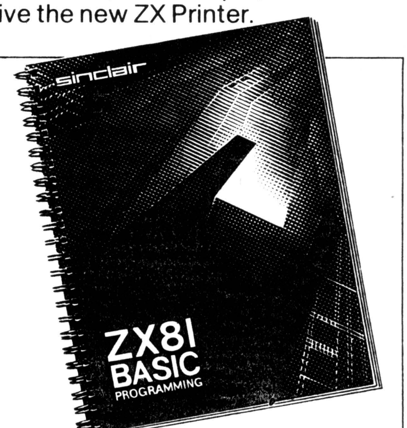
In March 1981, the Sinclair lead increased dramatically. For just £69.95 the Sinclair ZX81 offers even more advanced facilities at an even lower price. Initially, even we were surprised by the demand – over 50,000 in the first 3 months!

Today, the Sinclair ZX81 is the heart of a computer system. You can add 16-times more memory with the ZX RAM pack. The ZX Printer offers an unbeatable combination of performance and price. And the ZX Software library is growing every day.

Lower price: higher capability
With the ZX81, it's still very simple to teach yourself computing, but the ZX81 packs even greater working capability than the ZX80.

It uses the same micro-processor, but incorporates a new, more powerful 8K BASIC ROM – the 'trained intelligence' of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays.

And the ZX81 incorporates other operation refinements – the facility to load and save named programs on cassette, for example, *and* to drive the new ZX Printer.



New BASIC manual

Every ZX81 comes with a comprehensive, specially-written manual – a complete course in BASIC programming, from first principles to complex programs.

Kit: £49.95

Higher specification, lower price – how's it done?
Quite simply, by design. The ZX80 reduced the chips in a working computer from 40 or so, to 21. The ZX81 reduces the 21 to 4!

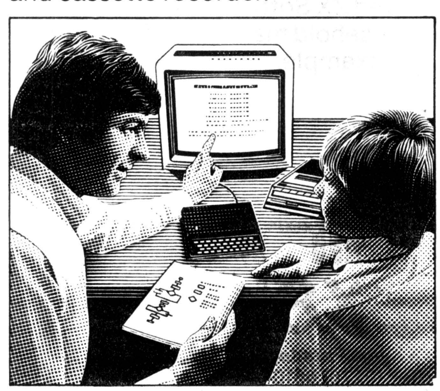
The secret lies in a totally new master chip. Designed by Sinclair and custom-built in Britain, this unique chip replaces 18 chips from the ZX80!

New, improved specification
- Z80A micro-processor – new faster version of the famous Z80 chip, widely recognised as the best ever made.
- Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tiresome typing. Key words (RUN, LIST, PRINT, etc.) have their own single-key entry.
- Unique syntax-check and report codes identify programming errors immediately.
- Full range of mathematical and scientific functions accurate to eight decimal places.
- Graph-drawing and animated-display facilities.
- Multi-dimensional string and numerical arrays.
- Up to 26 FOR/NEXT loops.
- Randomise function – useful for games as well as serious applications.
- Cassette LOAD and SAVE with named programs.
- 1K-byte RAM expandable to 16K bytes with Sinclair RAM pack.
- Able to drive the new Sinclair printer.
- Advanced 4-chip design: micro-processor, ROM, RAM, plus master chip – unique, custom-built chip replacing 18 ZX80 chips.

Built: £69.95

Kit or built – it's up to you!
You'll be surprised how easy the ZX81 kit is to build: just four chips to assemble (plus, of course the other discrete components) – a few hours' work with a fine-tipped soldering iron. And you may already have a suitable mains adaptor – 600 mA at 9 V DC nominal unregulated (supplied with built version).

Kit and built versions come complete with all leads to connect to your TV (colour or black and white) and cassette recorder.



uter-

Available now- the ZX Printer for only £49.95

Designed exclusively for use with the ZX81 (and ZX80 with 8K BASIC ROM), the printer offers full alphanumerics *and* highly sophisticated graphics.

A special feature is COPY, which prints out exactly what is on the whole TV screen without the need for further intructions.

At last you can have a hard copy of your program listings – particularly useful when writing or editing programs.

And of course you can print out your results for permanent records or sending to a friend.

Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch.

The ZX Printer connects to the rear of your computer – using a stackable connector so you *can* plug in a RAM pack as well. A roll of paper (65 ft long x 4 in wide) is supplied, along with full instructions.

16K-byte RAM pack for massive add-on memory.

Designed as a complete module to fit your Sinclair ZX80 or ZX81, the RAM pack simply plugs into the existing expansion port at the rear of the computer to multiply your data/program storage by 16!

Use it for long and complex programs or as a personal database. Yet it costs as little as half the price of competitive additional memory.

With the RAM pack, you can also run some of the more sophisticated ZX Software – the Business & Household management systems for example.

How to order your ZX81

BY PHONE – Access, Barclaycard or Trustcard holders can call 01-200 0200 for personal attention 24 hours a day, every day.

BY FREEPOST – use the no-stamp-needed coupon below. You can pay by cheque, postal order, Access, Barclaycard or Trustcard.

EITHER WAY – please allow up to 28 days for delivery. And there's a 14-day money-back option. We want you to be satisfied beyond doubt – and we have no doubt that you will be.

To: Sinclair Research Ltd, FREEPOST, Camberley, Surrey, GU15 3BR. **Order**

Qty	Item	Code	Item price £	Total £
	Sinclair ZX81 Personal Computer kit(s). Price includes ZX81 BASIC manual, excludes mains adaptor.	12	49.95	
	Ready-assembled Sinclair ZX81 Personal Computer(s). Price includes ZX81 BASIC manual and mains adaptor.	11	69.95	
	Mains Adaptor(s) (600 mA at 9 V DC nominal unregulated).	10	8.95	
	16K-BYTE RAM pack.	18	49.95	
	Sinclair ZX Printer.	27	49.95	
	8K BASIC ROM to fit ZX80.	17	19.95	
	Post and Packing.			2.95

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*I enclose a cheque/postal order payable to Sinclair Research Ltd, for £_____

*Please charge to my Access/Barclaycard/Trustcard account no.

*Please delete/complete as applicable.

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As a general purpose remote control in the home for switching lights, television and other appliances. This unit is ideal for the aged or disabled.

£23.75

ALL PRICES EXCLUDE VAT

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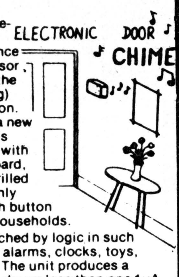
DL1000K
This value-for-money kit features a bi-directional sequence, speed of sequence and frequency of direction change, being variable by means of potentiometers and incorporates a master dimming control. **Only £14.60**

DLZ1000K
A lower cost version of the above, featuring undirectional channel sequence with speed variable by means of a pre-set pot. Outputs switched only at mains zero crossing points to reduce radio interference to a minimum. **Only £8.00**

Optional opto input DLA1 .... **60p**
Allowing audio ("beat")—light response.

DO YOU LONG TO HEAR YOUR DOORBELL RING?



Our latest kit gives you a pleasing three-note harmonically related tone sequence (not a microprocessor controlled buzz or the same old ding dong) at a touch of a button. This kit, based on a new integrated circuit, is supplied complete with a printed circuit board, loudspeaker and drilled box and requires only 9V battery and push button common to most households.
It may also be switched by logic in such applications as car alarms, clocks, toys, P.A. systems, etc. The unit produces a 150mW output and draws less than one 1uA from a PP3 battery when the tone ceases. Supplied complete with circuit and assembly instructions.
IDEAL PROJECT FOR BEGINNERS— ONLY £5.00

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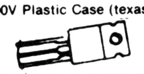
This new design is based on the ICL7126 (a lower power version of the ICL7106 chip) and a 3½ digit liquid crystal display. This kit will form the basis of a digital multimeter (only a few additional resistors and switches are required—details supplied), or a sensitive digital thermometer (−50°C to +150°C) reading to 0.1°C. The basic kit has a sensitivity of 200mV for a full scale reading, automatic polarity indication and an ultra low power requirement—giving a 2 year typical battery life from a standard 9V PP3 when used 8 hours a day, 7 days a week.
Price £15.50

TRIACS



400V Plastic Case (texas) 3A TIC206D	49p
8A TIC226D	58p
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Diac	18p
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2708	2.25	6810	1.25	M6802P(CPU)	3.85
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LS00	.12	LS14	.48	LS42	.40	LS93	.37
LS01	.12	LS15	.15	LS47	.42	LS95	.48
LS02	.13	LS20	.14	LS51	.15	LS107	.24
LS03	.13	LS21	.15	LS54	.15	LS109	.24
LS04	.14	LS22	.15	LS55	.15	LS112	.24
LS05	.15	LS26	.18	LS73	.20	LS113	.24
LS08	.15	LS27	.15	LS74	.18	LS114	.24
LS09	.15	LS30	.14	LS75	.27	LS123	.51
LS10	.14	LS32	.15	LS76	.21	LS126	.29
LS11	.15	LS37	.17	LS85	.64	LS132	.44
LS12	.15	LS38	.16	LS86	.18	LS160	.40
LS13	.27	LS40	.14	LS90	.32	LS161	.40

CMOS

4000	.14	4026	1.05	4093	.45
4001	.14	4027	.40	4501	.24
4002	.14	4028	.50	4511	.85
4007	.14	4040	.68	4514	1.80
4011	.15	4049	.30		
4012	.17	4050	.30		
4013	.35	4060	.90		
4015	.70	4069	.18		
4016	.30	4070	.24		
4017	.65	4071	.22		
4019	.38	4077	.24		
4023	.22	4081	.22		
4025	.18				

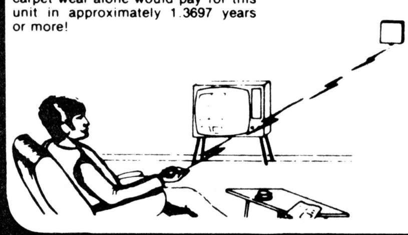
THE KEY TO YOUR SECURITY IS IN OUR LOCK

If the thought of car thieves, house breakers of people tampering with your electrical and electronic equipment upsets you, have just the kit for you.
Our ELECTRONIC LOCK KIT includes a 10-way keyboard and a special IC which provides a 750mA output to drive a solenoid or relay (not supplied) when four keys are depressed in the correct sequence. This gives over 5,000 possible combinations! The sequence is prewired and may be easily changed by means of a small plug and socket. A "SAVE" function is also available enabling the open code to be stored (especially useful in a car when it is left in a garage for servicing as the open code need not be disclosed). Size: 7x6x3 cms. Power Consumption is 40uA at 5V to 15V d.c.
At only £10.50 + VAT, it will make a smaller hole in your pocket than a bunch of keys!
Electric Lock Mechanism **£12.50**
Suitable for use with existing door locks and above electronic lock kit.

THE PERFECT AID FOR "LAZYITIS"

Our Lamp Dimmer Kit with INFRA RED REMOTE CONTROL will enable you to switch the lights on or off, and set the brightness, at a push of a button without leaving your armchair, water-bed, etc. Not only will you save time but it has also been estimated that the savings in shoe leather and carpet wear alone would pay for this unit in approximately 1.3697 years or more!

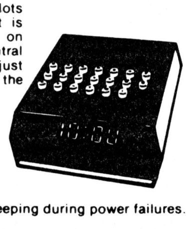
This unit has considerable practical uses, especially for the old, infirm and disabled. It works like a conventional dimmer, enabling you to switch the lights on or off, or to dim them to whatever brightness you require, by touch or using the hand-held infra red transmitter. When assembled, it fits into a plaster depth box to replace your conventional switch or dimmer with no rewiring.



TDR300K Dimmer Kit **£14.30**
MK6 Transmitter Kit **£4.20**
We also still sell our highly popular TD300K Touch Dimmer Kit at **£7.00** and the LD300K rotary controlled Dimmer Kit at .... **only £3.50**
All kits contain all necessary components and full instructions. You only need a soldering iron and cutters.

THE MULTI-PURPOSE TIMER HAS ARRIVED

Now you can run your central heating, lighting, hi-fi system and lots more with just one programmable timer. At your selection it is designed to control four mains outputs independently, switching on and off at pre-set times over a 7 day cycle, e.g. to control your central heating (including different switching times for weekends), just connect it to your system programme and set it and forget it— the clock will do the rest.

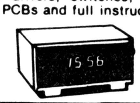


FEATURES INCLUDE—
★ 0.5" LED 12 hour display.
★ Day of week, am/pm and output status indicators.
★ 4 zero voltage switched mains outputs.
★ 50/60Hz mains operation.
★ Battery backup saves stored programmes and continues time keeping during power failures. (Battery not supplied).
★ Display blanking during power failure to conserve battery power.
★ 18 programme time sets.
★ Powerful "Everyday" function enabling output to switch every day but use only one time set.
★ Useful "sleep" function—turns on output for one hour.
★ Direct switch control enabling output to be turned on immediately or after a specified time interval.
★ 20 function keypad for programme entry.
★ Programme verification at the touch of a button.

THERE HAS NEVER BEEN A CLOCK CAPABLE OF SO MUCH AT SUCH A LOW PRICE— **ONLY £45.00**
(including components, assembly and programme instructions in an attractive case).

24 HOUR CLOCK/APPLIANCE TIMER KIT

Switches any appliance up to 1kW on and off at present times once per day. Kit contains: AY-5-1230 IC, 0.5" LED display, mains supply, display drivers, switches, LEDs, triacs, PCBs and full instructions.



CT1000K Basic Kit **£14.90**
CT1000K with white box (56/131 × 71mm) **£17.40**
(Ready Built) **£22.50**

Add 50p postage & packing + 15% VAT to total.
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PE VOLUME 18 No. 5 MAY 1982

TEST TEST TEST

This issue is a result of the many requests we get to publish more test gear. It seems that although we have been publishing regular test gear projects of various types you still want more. Our series of eight projects to fit the free case given with the May issue last year—yes, it's a year ago—were very popular and many of the instruments are now available ready made. The *Frequency Meter* published in this issue uses the same case and we can supply readers with these cases for 50p—details in the article.

Our most inventive test gear project is possibly the *Signature Analyser*. This item is quite a breakthrough in circuit design since it can perform the basic functions of instruments costing hundreds of pounds. For those familiar with signature analysis we feel this item will be very interesting. One other point on this project—the author is Yugoslavian and the project was sent to PE "out of the blue" from Yugoslavia. Yes we are read world wide and maybe the state of the art is at a higher level in some countries than we in the UK believe, or are led to believe. Incidentally, on the same theme, our eight page supplement comes from a South African author and contributors to Microbus come from Iceland, Portugal, Sweden and Hungary; a truly international edition!

ON THE BUS

Of course much commercial test gear is now being made outside of Europe and the US. We have included a good selection of what's new in *News and Market Place*—it comes from all over the place.

The bus approach to automatic test gear is interesting and it is now possible for small businesses and hobbyists to construct a system using available chips, a few details are given in the supplement. If anyone is doing this or is interested in so doing please let us know. We could possibly arrange a series of projects on the subject given sufficient interest. It's your magazine so let us know how you feel about what we publish—or what we don't!

BAZAAR

If you are looking for test gear—or almost anything else in the hardware line—a scan through *Bazaar* might be worthwhile. This new feature in PE really finds its feet this month with about 90 ads. appearing—keep them coming, it's good for everyone.

Just a couple of points on *Bazaar* now it is in full swing. First, you must send in a *cut out valid* date corner—a copy of one will not do. Second, you must comply with the rules. Since the service is free to readers, in future we will not be writing to you if you do not comply with the above—your ad. will simply not appear. So make sure your ad. complies with the rules and make sure you send a cut out valid date corner—we don't need the whole page or even the whole coupon, if you want to keep your issue send us a copy of the coupon; but you must cut off the corner and send that in. It's not too much to ask and it is then fair to everyone.

Mike Kenward

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Technical Queries

We are unable to offer any advice on the use or purchase of commercial equipment or the incorporation or modification of designs published in PE. All letters requiring a reply should be accompanied by a stamped, self addressed envelope, or international reply coupons, and each letter should relate to **one published project only.**

Components and p.c.b.s are usually available from advertisers; where we anticipate difficulties a source will be suggested.

Back Numbers

Copies of most of our recent issues are available from: Post Sales Department (Practical Electronics), IPC Magazines Ltd., Lavington House, 25 Lavington Street, London SE1 0PF, at 95p each including Inland/Overseas p&p.

Binders

Binders for PE are available from the same address as back numbers at £4·60 each to UK or overseas addresses, including postage and packing, and VAT where appropriate. Orders should state the year and volume required.

Subscriptions

Copies of PE are available by post, inland or overseas, for £13·00 per 12 issues, from: Practical Electronics, Subscription Department, Oakfield House, Perrymount Road, Haywards Heath, West Sussex RH16 3DH. Cheques and postal orders should be made payable to IPC Magazines Limited.

...news &

Edited by Jasper Scott

Better than credit

A new era in buying petrol, with a debit card authorising the payment from a motorist's bank account in four seconds flat, began recently, in Scotland.

The debit card relies on micro-chips to carry out direct bank account deductions. And, say BP Oil and Clydesdale Bank, who are launching the new scheme in Aberdeen, this kind of debiting is what most motorists want.

Mr Chris Ensor, BP Oil's Site Facilities Manager, says, "Eight out of 10 motorists like to pay for petrol with cash. They regard petrol as a household expense along with groceries, which are accounted for in weekly or monthly budgets. In money terms they like to know where they are."

The scheme is called 'Counterplus'. Designed for customers with AutoBank cards issued by Clydesdale, Midland and Northern banks, it is the first time in the UK that a point of sale terminal, as opposed to a cash dispenser, has been linked directly and instantaneously to a bank.

Customers using this new facility won't need to hand over cash, to write a cheque or to wait while a credit card voucher is made out. They will simply use their cards, in the same way that they draw cash, to pay for garage purchases.

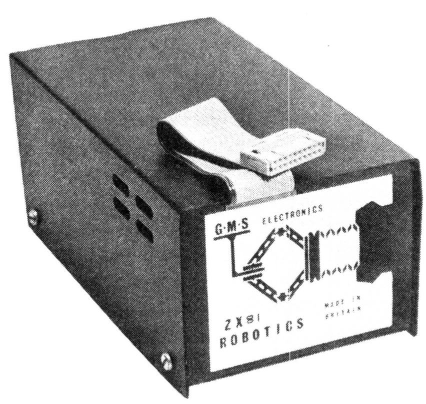
Looking further into the future Mr Ensor predicts that within five years most of Britain's prime service stations will be using an electronic fund transfer system like this.

ZX81 ADD-ONS

A robot interface unit has been developed by GMS Electronics for the ZX81 microcomputer. The mains powered unit's steel case measures just 100 × 70 × 180mm, and with 16 channels, of which the 8 inputs are rated at 1A each the unit is a general purpose interface. It would, for example, conveniently drive a shop lighting display, or electromechanical machinery.

The I/O channels run at 6-12V nominal with a maximum rating of 48V, with external supply. Inputs are protected, and the outputs incorporate anti-spike devices.

An applications book with interconnection circuit diagram, instructions and simple programming are included in the price of £59·95, plus £2·50 p&p. Available from GMS Electronics, Unit 5, Cranbourne Close, Norbury, London SW16 4NG.



Owners of the popular ZX81 personal computer can now upgrade from its rather immobile membrane keypad, and flimsy case (albeit smart in appearance) to a conventional keyboard with steel surround. The Crofton ZX81 Adaptakit places the ZX81 piggy-back on its own p.c.b. which houses the key-switches, *and* a video amplifier for direct monitor interface. A l.e.d. also gives indication of 'power on'.

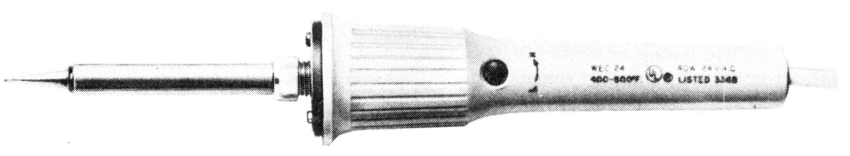
The ZX80 p.c.b. is positioned so that its input and output connectors pass through holes in the Crofton case. The 16K RAM pack may also be plugged in through an aperture, and a support plate is provided to remove strain from the p.c.b. edge connector.

The key caps are made of clear plastic so that the symbol for any function may be inserted, and will not wear away. A two-colour, self-adhesive sheet of key-top labels comes with the kit. This gives a direct repeat of the ZX81's original keyboard.

With berillium contacts, the switches should provide one million trouble free operations.

The kit's fully inclusive price is £42·90. However, for an additional £8·62, plus a pristine cased ZX81 in part exchange, a ready converted system is available. Crofton Electronics Ltd., 35 Grosvenor Road, Twickenham, Middlesex TW1 4AD.

TEMPERATURE CONTROLLED IRON



The Weller WEC series are fully proportional electronic temperature controlled soldering irons. These irons give excellent response to loading and provide precise temperature control. Although they are factory calibrated to 371°C (700°F), they are fully user adjustable over a range of at least 204°C (400°F) to 427°C (800°F), and are available in three voltages ranges—240, 120 and 24V. The temperature control and circuitry is contained within the handle.

The WEC series of irons is available from Toolrange Ltd., Upton Road, Reading, Berks (0734 22245).

MARKET PLACE

Items mentioned are available through normal retail outlets unless otherwise specified. Prices correct at time of going to press.

Briefly...

The Powertran advert on the inside front cover of last month's issue contained an error. In the advert, it was stated that the price for the complete kit of parts for the Digital Delay Line was £13.00 plus VAT. The correct price for the complete kit is £130.00 plus VAT.

● ● ● ●

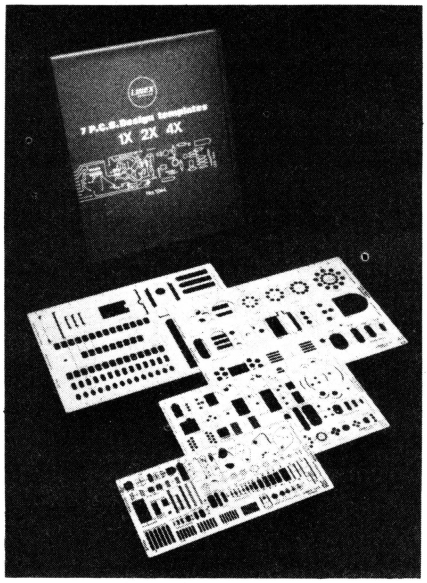
A new company has recently been formed to provide hobbyists, experimenters and small companies with high quality technology products. Initially, the company aims to concentrate on three areas—production tools/equipment, test gear and microelectronic products. Further details are available from Electronic Hobbies Ltd., 17 Roxwell Road, Chelmsford, Essex (0245 62149).

POINTS ARISING . . .

TV CAMERA (Jan–March '82)

The telephone number given for Security Electronics contained a printing error. The correct number is: 0733 239111.

PCB DRAFTING AIDS



A new range of electronic layout templates for printed circuit design has recently been introduced by LINEX of Denmark, and is of particular interest to both amateur and professional users who are involved in the design or production of printed circuit boards.

The templates are available in the scales of 1:1 (one template), 2:1 (set of 2) and 4:1 (set of 4) and they contain the most commonly used figures for printed circuit layouts, circuit views and component views. Component outlines include potentiometers, diodes, resistors, capacitors, dual in line, transistors, edge connectors etc., etc.

All component dimensions and terminals are given in millimetres and in tenths of inches, and dimensions are provided with mm and 0·1" divisions in the respective scales. All the templates in the series are produced with ink bosses so that they can be used for tracing with technical pens.

A comprehensive leaflet illustrating the templates is available and this leaflet suggests methods and instructions on how best to use the templates. For a free leaflet, or any other information, contact the sole UK agents for LINEX, Pelltech Ltd., Station Lane, Witney, Oxon (Telephone: Witney (0993) 72014 or 72130).

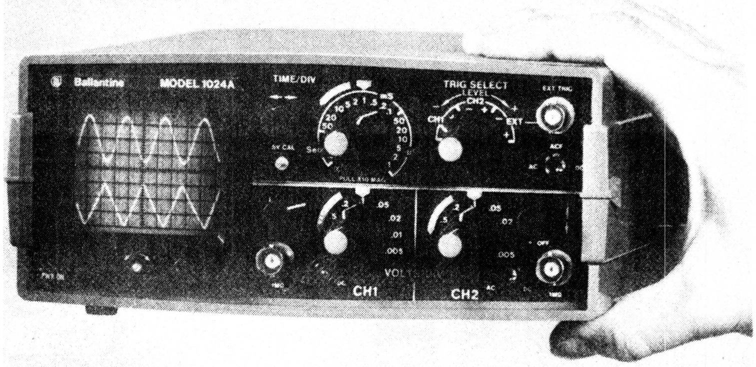
Countdown...

Please check dates before setting out, as we cannot *guarantee* the accuracy of the information presented below.

Local Networks & Distributed Office Systems Apr. 14–16. The London Tara Hotel. **O**
Int. Materials Handling Apr. 19–26. Earls Court, London. **I**
All Electronics Show Apr. 20–22. Barbican Centre, London. **E**
Communications Apr. 20–23. NEC. **I**
The Computer Fair Apr. 23–25. Earls Court, London. **Z1**
BEX Brighton Apr. 28–29. **K**
Compec Europe May 4–6. Centre Int. Rogier, Brussels. **Z1**
Defence Components Expo May 10–12. Brighton Metropole. **I**
The Micro Show May 11–13. Wembley Conf. Centre. **O**
HEVAC May 24–28. NEC Birmingham. **I**
Scotelex Jun. 8–10. Roy. Highland Ex. Hall, Ingliston, Edinburgh. **A1**
BEX Leeds Jun. 9–10. **K**
Transducer/Tempcon Jun. 29–Jul. 1. Wembley Conf. Centre. **T**
BEX Croydon Jun. 30–Jul. **K**
Leeds Electronics Show Jul. 6–8. University. **E**
BAEC Amateur Electronics Jul. 17–25. Penarth Esplanade, S. Glamorgan. **B9**
Personal Computer World Show Sept. 9–12. Barbican Centre, London. **M**
Laboratory London Sep. 14–16. Grosvenor House. **E**
Two Counties Fair Sep. 15–18. Plymouth Ex. Centre, Millbray, Plymouth, Devon. **T**
Viewdata Oct. 12–14. Wembley Conf. Centre. **O**
Computer Graphics Oct. 19–21. London. **O**
Testmex Oct. 26–28. Wembley Conf. Centre, London. **T**

A1	Institute of Electronics, Rochdale, Lancs.
B9	BAEC, 26 Forrest Road, Penarth
E	Evan Steadman, Saffron Walden ✆ 0799 22612
H1	Seminex Ltd. Tunbridge Wells ✆ 0892 39664
I	ITF, Solihull ✆ 021-705 6707
K	Douglas Temple, Bournemouth ✆ 0202 20533
L1	World Trade Centre ✆ 01-488 2400
M	Montbuild ✆ 01-486 1951
O	Online, Northwood, Middx. ✆ 09274 28211
T	Trident Tavistock ✆ 0822 4671
V	SDL ✆ Dublin 763871
Z1	IPC Exhibitions, Sutton ✆ 01-643 8040

BALLANTINE PORTABLE



The new Ballantine 1024A mini oscilloscope, available from PPM Limited, has been designed to suit the needs of the field engineer, and light weight and small size have been achieved without reduction in instrument perforn.ance. The 1024A's specification is equal to laboratory bench scopes two or three times larger and heavier; it is shock and weather proof and will operate in harsh environments. The 1024A weighs 2·1 kilos and measures 87mm × 203mm × 220mm.

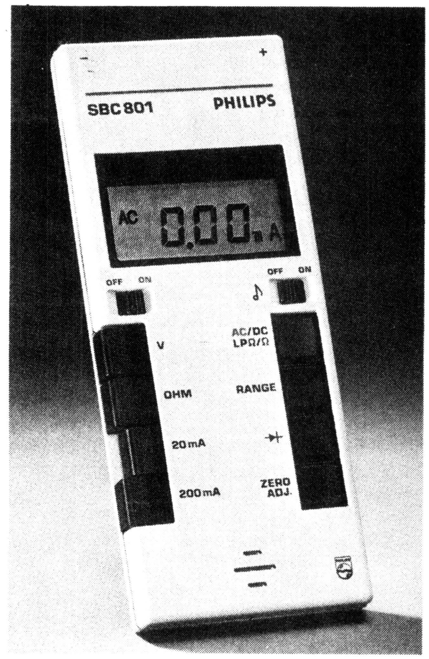
The Ballantine 1024A complements the existing 15 MHz model 1022A, also marketed in the UK by PPM, and gives extended performance with a 25MHz bandwidth in each of its two vertical input channels. The wide 25MHz frequency response extends 1024A use to fast signals, and the instrument has a passive delay line, so that the leading edge of fast rise pulses can be displayed when using internal triggering.

1024A applications include general purpose testing and maintenance in analogue and digital circuits, RF communications systems, computer peripherals, video equipment, industrial and process control systems, in telecommunications, medical instrumentation, and other fields.

PPM say that the scopes are reliable and run with less than a 9°C hot -spot rise in ambients from 0° to 50°C. The containing cases are dust, splash, and EMI proof. The shock and vibration resistant CRT and solid internal construction of the 1024A make it dependable in demanding field conditions.

Further information is available from PPM Ltd., Hermitage Road, St. Johns, Woking, Surrey GU21 1TZ (04867 80111).

PHILIPS SERVICE...

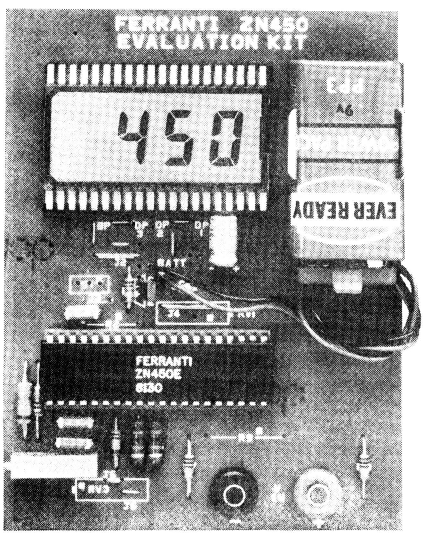


A range of test equipment is now available from Philips Service, Croydon. While much of the test gear they have to offer is very up-market—both in terms of price and performance, there are items in their range to suit the hobbyist pocket.

Pictured above is the Philips SBC801 pocket autoranging DMM. Its features include an alarm for continuity test work, a diode check range and zero adjust function. The SBC801 is supplied complete with test leads, carrying case and batteries, and is priced at £55·95 plus VAT.

A digital logic probe, a range of three analogue multitesters and a regulated 1·5–30V 3A power supply are among other items in the Philips range which may be of interest to readers.

For further details, contact Philips Service, 604 Purley Way, Waddon, Croydon, Surrey CR9 4DR (01-686 0505).



EVALUATION KIT FOR DVM

Ferranti Electronics Limited has produced an evaluation kit for its ZN450, 3½ digit, single-chip, digital voltmeter integrated circuit. The kit includes a ZN450 and all the peripheral components and instructions necessary to produce a complete digital voltmeter. The kit enables designers and engineers to evaluate the performance of the ZN450 i.c. without the problems of designing and constructing a system from scratch.

The ZN450 is a complete digital voltmeter fabricated on a monolithic chip and requires only ten external passive components in order to function. Operating over the range ±199·9mV, the ZN450 also features an on-chip clock and precision reference voltage and consumes less than 35mW of power.

Apart from the more obvious uses as a DVM or multimeter, the ZN450 can equally well be applied to such devices as digital thermometers, pressure gauges and weighing machines.

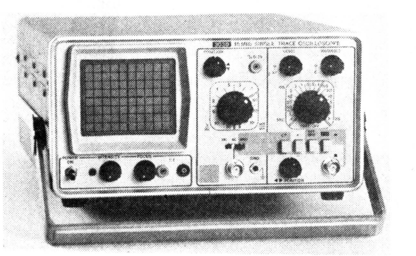
The DVM evaluation kit is priced at £19·95 including VAT, and is available through normal retail outlets.

TEST GEAR SPECIAL...

CROTECH SCOPES

Crotech Instruments Ltd., presently offer two 15MHz oscilloscopes—a simple trace model—the 3030, and a dual trace model—the 3131.

The 3030 (pictured here) has 5mV/div sensitivity, versatile time base with 200ns/div to 20ms/div sweep plus automatic and trigger level controls, triggering to at least 20MHz. A rectangular 95mm CRT gives around 40 per cent more viewing area than most competitive models.

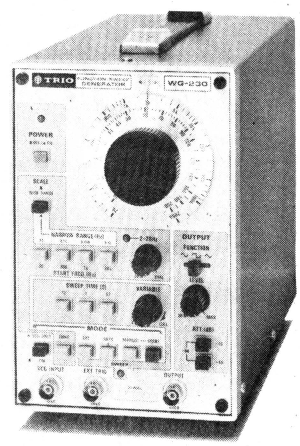


The 3131 features 5mV/div sensitivity with full X-Y operation plus the extra feature of algebraic addition and subtraction. The timebase is fully constructed from 200ns to 0·2s/div with a versatile trigger circuit which operates to at least 35MHz and includes TV Field and line frequency modes.

Both models feature a built-in component tester which allows both passive and semiconductor devices to be tested.

The 3030 is priced at £145 plus VAT, and the 3131 is priced at £230 plus VAT. Further details are available from Crotech Instruments Ltd., 5 Nimrod Way, Elgar Road, Reading, Berks (0734 866945).

FUNCTION, SWEEP & PULSE GENERATOR



House of Instruments inform us that they now stock the WG 230 from Trio, which combines the capabilities of a Function, Sweep and Pulse Generator in one compact unit. The wide frequency bandwidth is covered by a log and linear divided, high resolution main dial from 20Hz to 200kHz, with an auxiliary control covering the range 2Hz to 2GHz.

Four main types of output are available: Sine, Square, Triangle and TTL level Pulse. Output impedance is 600ohms with 7V r.m.s. sine and 10V pk to pk for square and triangle controlled by 60dB's of switched and 20dB's of variable attenuation. Flatness is better than 0·2dB making the WG230 ideal in determining frequency characteristics. The TTL pulse output can be used to drive logic circuitry or act as a clock source substitute. FM modulation, another convenient feature when measuring frequency characteristics over a specific band, is available via an external signal. External d.c. can be used for VCO applications while a useful sweep ramp output is provided for use as a time access control for oscilloscopes or pen recorders.

Up to five frequency decades can be covered in a single sweep with automatic sweep times being internally selected from 0·1 to 100 seconds both continuous and single to match the application. The single sweep mode can also be controlled manually from the front panel or sweep speeds determined by external signals. Automatic sweep speed compensating has been provided to maintain a constant sweep time period for any arbitrarily set width.

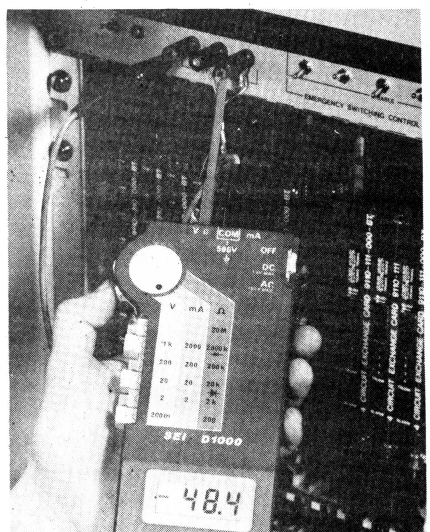
For further information, contact House of Instruments, Clifton Chambers, 62, High Street, Saffron Walden, Essex CB10 1EE. (0799 24922).

NEW SEI DMM

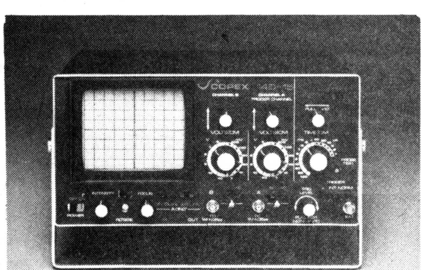
A new hand-held digital multimeter, designed for wide application in the computer and telecommunications testing and servicing markets, has been announced by SEI.

The input terminals are at the top, enabling the operator to 'probe' the circuit under test, whilst holding the instrument in one hand. The $3\frac{1}{2}$ digit l.c.d. display is at the base, and is sloped for easier reading. The meter covers a resistance range of 0 to 20MΩ, with diode test facility, and a voltage range 0 to 1kV (max) d.c. and 0 to 750V r.m.s. (max) a.c.

Further information is available from Salford Electrical Instruments Ltd., Barton Lane, Eccles, Manchester M30 0HL (061-789 5081).



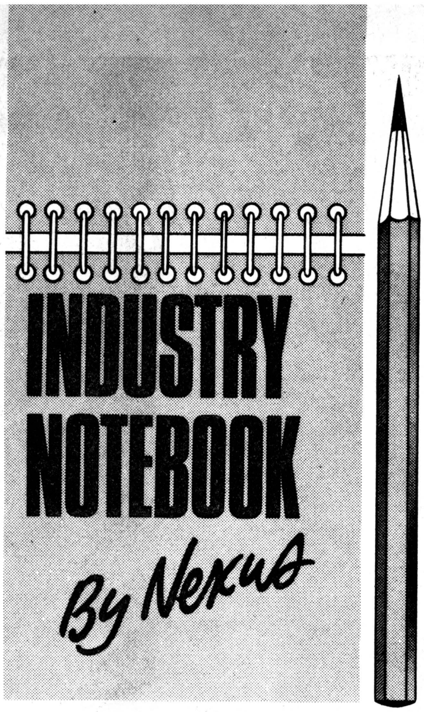
SCOPEX



Scopex Instruments Ltd. of Letchworth, the independent British manufacturers, have announced an addition to their range of low cost, high performance oscilloscopes.

Designated the 14D15, this instrument is a 15MHz dual trace oscilloscope incorporating push button X-Y, add and invert facility, probe compensation and an active TV sync separator all as standard features.

This instrument was evolved from the 14D10 series of oscilloscopes. The 14D15 is priced at £250·00 plus VAT, which includes two probes and carriage (UK mainland). Further information is available from Scopex Instruments, Pixmore Avenue, Letchworth, Herts SG6 1JJ (04626 72771).



That Word!

Whoever coined the word privatisation deserves a kick up the backside or a medal, I hardly know which. It is clumsy, even ugly, and yet it is hard to find another single word to express the process of transferring public (i.e. nationalised) industry to private capital and management in the interests of economic efficiency and improved customer service.

As well as being an ugly word, it must be an ugly idea to many of those who have enjoyed sheltered as well as profitable occupation through the years. It comes hard when one is faced with the cold (or hot?) blast of competition.

The mere threat of privatisation has positive effects. The partial breach of the telecommunications monopoly, for example, has already gingered up British Telecom. Chairman Sir George Jefferson is reported to have sent senior management and the trade unions a sharp note on poor performance and high overheads. BT pay went up 31 per cent last year for only a 4·6 per cent increase in business. And compared with their US counterparts BT field engineers made only half as many service calls a day.

BT in fact had a remarkable turnround in its last half-year results, turning in £140 million profit compared with a £19 million loss in the same six months a year earlier. But this was mainly due to jacking up the cost to subscribers and had little to do with performance.

Alongside the appeal for greater efficiency there is also promised a revision of accounting policies and asset valuations. It is hinted that a more rational accounting system would reveal that profits are lower than claimed in the past.

The fact is that 'cooking the books' is by no means unknown in Government and, one assumes, in the organisations it directly supports and controls. This has been made abundantly clear by Joel Barnett who was Financial Secretary to the Treasury under Chancellor Denis Healey in the years 1974–79. In his recently published book Inside the Treasury', Joel Barnett writes that his previous experience as an accountant in juggling figures was as nothing to what he found in the Treasury with their 'massaging' and 'fudging' in presenting huge public expenditure figures.

Of course there is nothing criminally dishonest in such practices. Any set of statistics can be presented in many different ways and it is only human to put the best construction on them from your own viewpoint.

Nonetheless, if you are in business, which BT now is, rather than politics, then it should be beneficial to look hard facts in the face if the corporation is to be efficiently conducted.

The Micro

The message seems to be getting through that we are in the computer age. Advance publicity generated almost 100,000 enquiries for the BBC's Computer Programme. But what a pity there were technical difficulties (since resolved) that resulted in the series having to start with so few of the Acorn computers having been delivered to eager viewers. Production was speeded up to 2,000 a week to meet the demand. The BBC was just as embarrassed as the computer manufacturer but promises a repeat of the course for late starters.

Meantime Clive Sinclair is re-establishing his reputation as a whizz-kid with his ZX81 personal computer selling world-wide in its tens of thousands. And there are plenty of other makes to suit all pockets continually appearing.

But while a mass market for micros is now growing fast, the other bright mass-market hope of CB Radio has fallen short of expectations although not entirely a flop. Forbidden fruit is always sweeter and I note that now that CB is legal, in my area activity has fallen away rather than increased and nobody seems to have switched to legal f.m. from illegal a.m.

Research

The 1981 Annual Review, which has just arrived on my desk, from the Allen Clark Research Centre makes good reading. One hears so much of cuts in research spending, real or imaginary, from the universities that it is easy to start believing that working for the future has almost ceased. This is patently not so at the Plessey think tank and laboratories at Caswell, named after Plessey founder Allen Clark and established there since 1940.

J. C. Bass, managing director of the Allen Clark Research Centre, comments that: 'The competition to convert research and development into manufactured products increases in pace year by year and, correspondingly, electronic systems and devices become rapidly outdated and cease to be viable commercially. The race is an international event, there are some very strong competitors and we do not set the rules for it'.

I will give just one example of what he means. In a paper 'Monolithic Surface Acoustic Wave Convolver—Its Application to Spread Spectrum Communications' J. J. Purcell of the Integrated Circuits Division records in his conclusion that this device is being actively developed in France, USA, Germany and Norway as well as in the UK. Although he doesn't say so possibly in the Soviet Union as well.

Flux

The electronics industry more so than most is in a constant state of flux. There are not only the great leaps in technology but also in the structure and goals of companies. Thus, Plessey has been streamlining and shedding peripheral activities to concentrate on mainline products. One of the early companies sold off was Garrard, a steady loss-maker at the time. Regrettably Garrard's new owners, based in Brazil, found they couldn't compete in the world hi-fi market by continuing production in the UK and it has now been transferred entirely to Brazil where production costs are lower.

Latest company to be shed is Plessey Resistors which will stay in the UK trading under the new name Citec. New owners are Ron Clark, formerly managing director of Plessey Components Division and two high-ranking Plessey colleagues including the MD of Plessey Resistors, David Stapleton, now MD of Citec. The purchase has bank support and the project is expected to obtain ample investment from the City. The workforce at Swindon is being retained and there is already talk of expansion.

There are now a number of examples where ex-employees have bought companies and the trend is likely to continue.

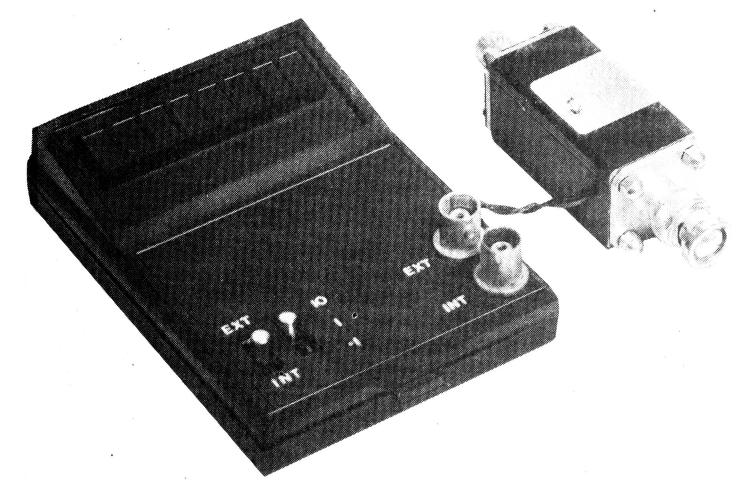
New Dimension

The Engineering Council, under the chairmanship of Sir Kenneth Corfield (chairman of STC), is now in existence after 18 months of wrangling over aims and objectives following publication of the Finniston Report which proposed enhancement of the 'engineering dimension' in British industry and education.

The Council's prime job will be to accredit academic courses and industrial training and to register engineers in their various categories. It's early days yet and until we have seen the Council in action, judgement must be reserved on whether there is any real improvement in the status of the engineer in society.

Embedded Optics

An ingenious combination of optical fibre and power line has been developed by BICC. The optical communications link is at the centre of an overhead power conductor, normally the earth line of an overhead power distribution system. The line will normally carry operational data, alarm signals and generating board messages. The first operational system should be installed in the UK over a 23km link by May this year, followed by a 74km system in Saudi Arabia under a £750,000 contract. A novel aspect of the system is that surplus capacity in the optical link can be leased to PTTs for public telephone use.



FREQUENCY METER AND PRESCALER

STEPHEN IBBS

THE project described here is a highly sensitive 200MHz 8-digit frequency meter, and, depending on the input waveform, will measure down to d.c. The prototype toggled at up to 220MHz! It uses the case given free by *Practical Electronics* last May. This measures approximately 102mm by 77mm by 25mm, and it will house a 9V battery, a 10-200MHz pre-amp and divide by 100 prescaler; switching logic, and the main 0-10MHz counter. Also packed in are two switches, two BNC sockets and an 8-digit display! All this shows that the constructor has to solder neatly, and take care with the mechanical side of the project. The meter is sensitive enough to require only a small piece of wire as an aerial pick-up; it has three gate times, and the logic provided to enable other inputs to be fed into the counter (using the second BNC socket) thus bypassing the preamplifier and *prescaler,* which is the unit described in *P.E. in April 1980.*

CIRCUIT DESCRIPTION

The main counter is the Intersil 7216B (0-10MHz) counter, which interfaces directly with an 8-digit display without the need for external driver i.c.s, using a 10MHz quartz crystal timebase. There are four versions of this i.c.

A = Universal counter. Common anode display,
B = Universal counter. Common cathode display (used in this project)
C = Frequency meter only. Common anode display,
D = Frequency meter only. Common cathode display.

The B version is a 28-pin d.i.l., and will measure:

a) Frequencies, up to 10MHz,
b) The ratio between two frequencies, feeding the second signal into pin 2.
c) Periods
d) Unit counts (e.g. useful for conveyor belts)
e) Time intervals, again using the second input.

It is only slightly more expensive than the 7216D, and provides so many more facilities that the author believes it to be worthwhile. The B was used in preference to the A because Common cathode 8-digits were available in the author's shack. The pin-outs are different for each version.

It has four gate times: ·01, ·1, 1, and 10 seconds, with full 8-digit accuracy provided on the 10 second gate. The ·01 gate is not used in this project because its usefulness is limited in frequency mode, and it enables the much more common, and cheaper, three way slide switch to be used. D1, D2, or D3 is connected via this switch to go to pin 14 to select the different gate times.

The 7216B will drive the displays direct, including the decimal points, but this is meaningless if a divide-by-100 prescaler is employed in front of the i.c. The Intersil data booklet provides details for external transistor drivers for the decimal point, but the limitation of space prevented these being included. If constructors require more information, they are referred to the booklet of lengthy code (408)996-5000TWX:910-338-0171.

The counter is a low power CMOS device, so handling precautions are needed and the total project will consume over 100mA. So if a rechargeable battery is not being used, constructors should be frugal about how long they leave the meter on!

Because of space the extra functions are not used (but could be if a slightly larger box was used, of course), so pin 3 (function input) is permanently connected to the Do line (pin 4) to make the i.c. function as a frequency counter.

For those who are interested:

D1 (pin 6) is for frequency ratio
D3 (pin 7) is for unit counter
D4 (pin 9) is for time interval
D7 (pin 12) is for period measurements.

These could be connected to pin 3 via a rotary switch.

The pre-amplifier and prescaler used in the project consists of an amplifier based on the BFY90 (with two diodes to limit the voltage on the base to 0·6V), the base bias set by a preset and the output capacitively coupled to the input of the divide-by-100 prescaler SP8629. This is an i.c. of excellent value, toggling in excess of 200MHz. It will tend to self oscillate in the absence of an incoming signal, but this can be prevented by placing a resistor between pin 6 (the negative edge triggered input) and earth. It provides TTL output and can be coupled direct to the ICM7216B. However there is space on the main p.c.b. for a 74LS132 to be inserted after the SP8629 to provide logic switching, enabling a second input, bypassing the preamp/prescaler, to be fed into the counter. The author found that the circuit worked most reliably when the resistor between 6 and earth is 27k, and the resistor between pin 7 and earth is omitted. Constructors may like to experiment to get the best performance.

It is because the author had already built this module that the project has two p.c.b.s; it saved the bother of designing a master p.c.b. The prototype has the prescaler board mounted in the battery compartment with the battery placed between the two boards. This enabled the switches and sockets to be mounted symmetrically above the prescaler board, being more shallow than the battery, but this necessitated

INTEGRAL PREAMP/PRESCALER

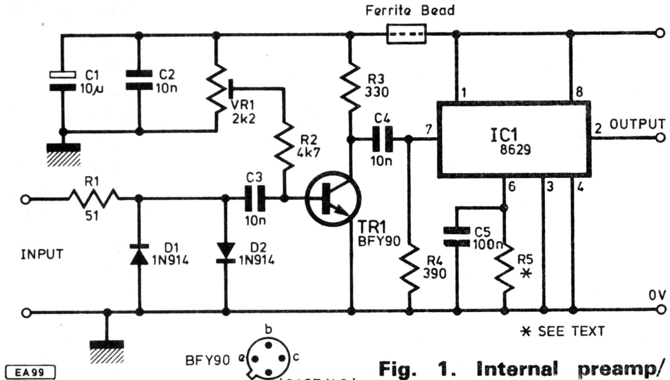


Fig. 1. Internal preamp/prescaler (÷100) circuit diagram

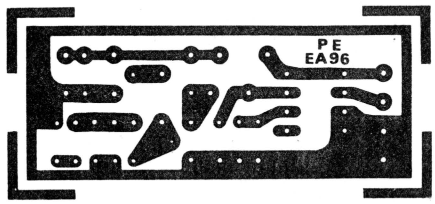


Fig. 2. Internal prescaler p.c.b. design

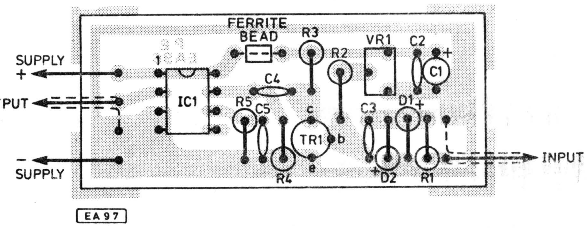
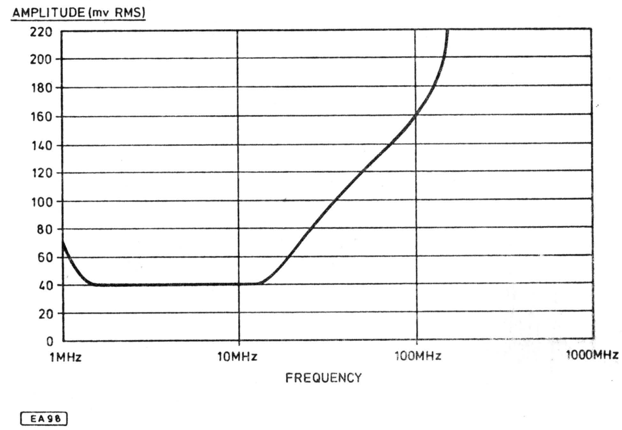


Fig. 3. Component layout

Fig. 4. Response curve of preamplifier/prescaler



COMPONENTS . . .

INTERNAL PREAMP PRESCALER

Resistors

R1	51
R2	4k7
R3	330
R4	390
R5	See text

All resistors ¼W 5% carbon

Potentiometers

VR1	2k2 sub. min vertical preset

Capacitors

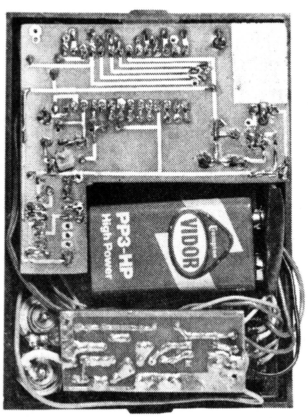
C1	10µ tant.
C2, C3, C4	10n ceramic (3 off)
C5	100n ceramic

Semiconductors

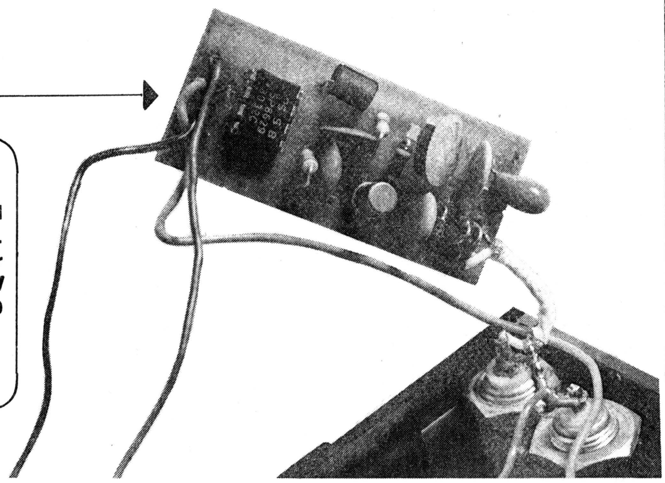
TR1	BFY 90
D1,D2	1N914 (2 off)
IC1	8629

Miscellaneous

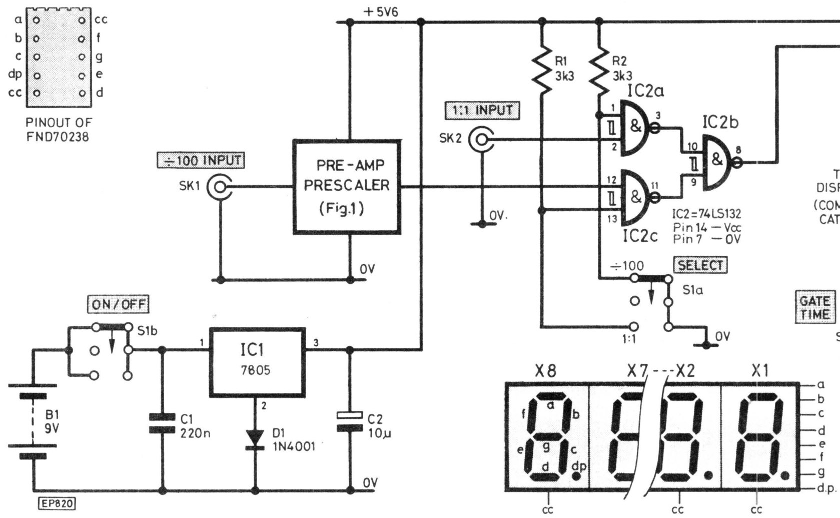
Ferrite anti-parasitic bead
p.c.b.
In line circuit module (RS 456–201)



÷100 prescaler and preamplifier module. This is the prescaler published in *Practical Electronics,* April 1980 issue.



Alignment of the prescaler is simply a matter of setting the d.c. potential at the collector of TR1 to half the supply voltage by varying VR1. The value of R5 is a compromise between open-circuit stability and overall circuit sensitivity.



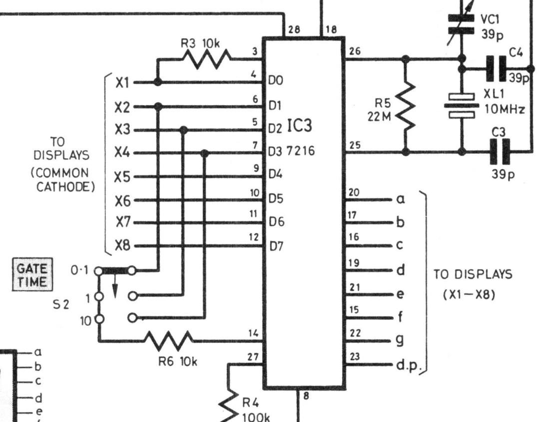
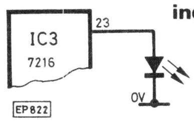
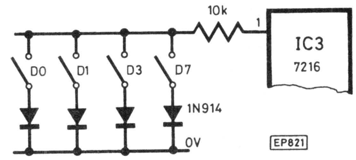


Fig. 7. Control input

Fig. 5. Overall circuit diagram of frequency meter. Note: The FND70238 display is compatible but obsolete. The FND357 should be used. R5 may be 10M

Fig. 6. Overflow indicator





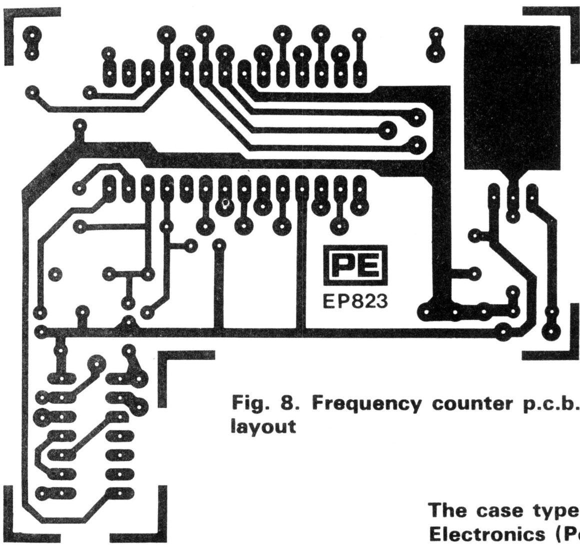


Fig. 8. Frequency counter p.c.b. layout

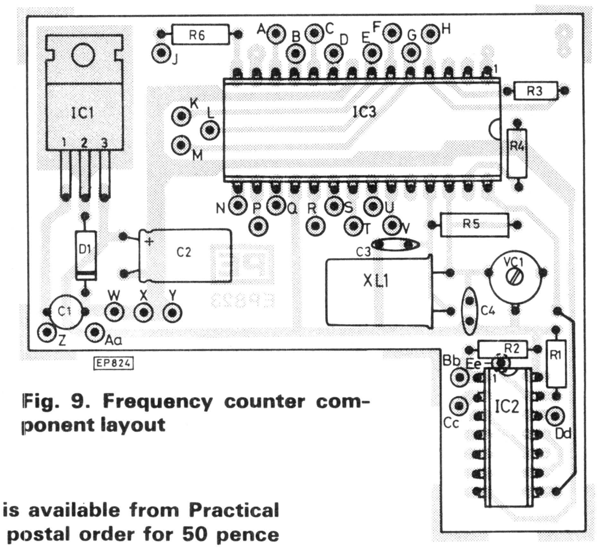
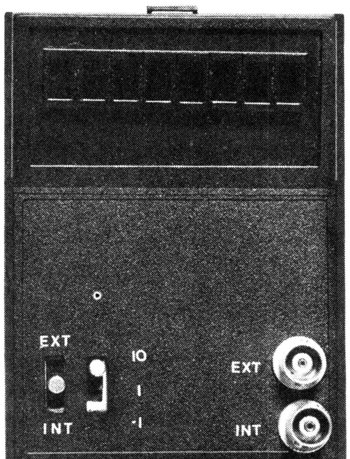


Fig. 9. Frequency counter component layout

The case type shown here is available from Practical Electronics (Poole). Send a postal order for 50 pence to include P&P etc.



COMPONENTS . . .

FREQUENCY COUNTER

Resistors

R1, R2	3k3 (2 off)
R3, R6	10k (2 off)
R4	100k
R5	22M

Capacitors

C1	220n
C2	10µ
VC1	39p

Display

X1-X8	FND357 (8 off)

Integrated Circuits

IC1	7805
IC2	74LS132
IC3	7216B

Miscellaneous

S1, S2 Three position slide switch (2 off)
X1 10MHz crystal
SK1, SK2 50Ω BNC socket (2 off)
Case
PP3 Battery plus stud connector
Printed circuit board

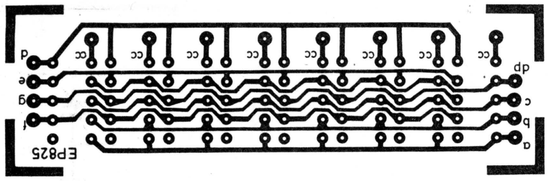


Fig. 10. Display board p.c.b. layout

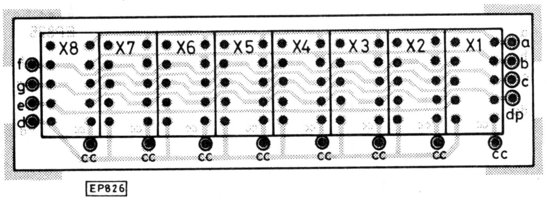


Fig. 11. Component layout. Capacitors need only be soldered on track side

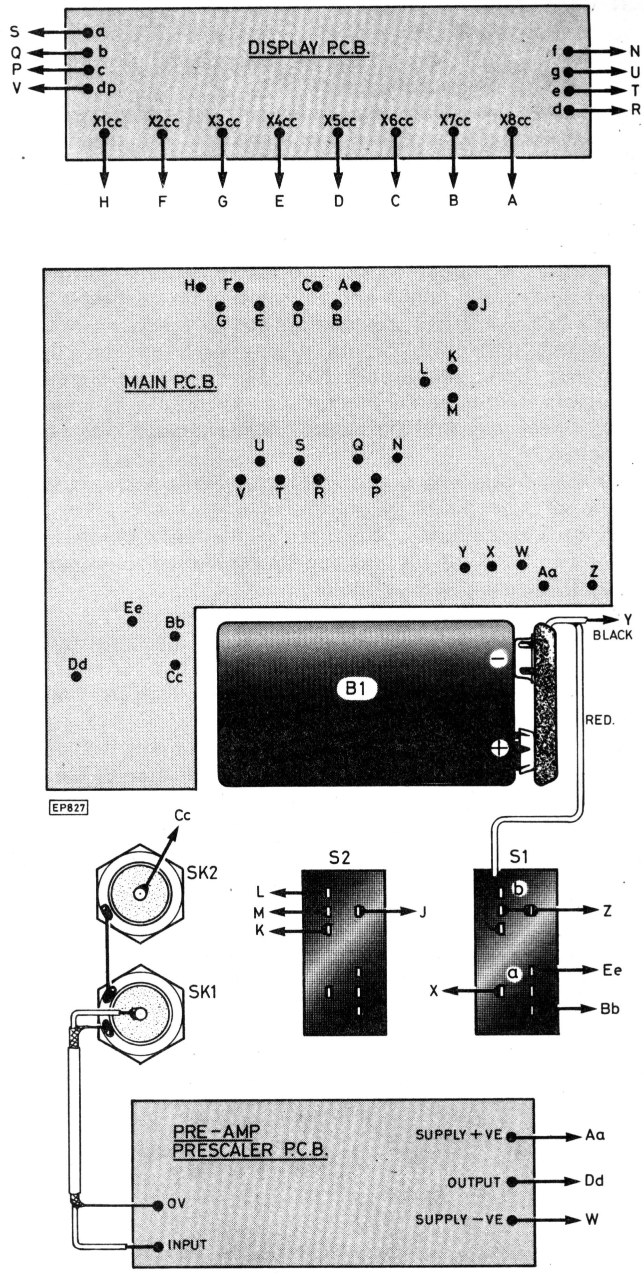


Fig. 12. Point-to-point wiring diagram. Wiring connections to the display board should be made direct to the reverse (copper) side. Wiring at the slide switches will depend on the type used. The d.p. line (V) is not used

longer lengths of interconnecting wire. Constructors may well decide to place the two boards together, but care will then have to be taken with the switch and socket positions, because of the bulk of the battery.

The output of the SP8629 is connected to pin 12 of IC2, and reference to Fig. 5 will show how it works. Each gate is a two-input nand gate, and the output of this gate is held high when one or other of the inputs is low. So if pin 1 is earthed via S1a, pins 3 (and 10) are high, and because 13 is high (due to R1 pulling it up to supply +ve) it allows frequencies on pin 12 to go through to pins 11 and 9, and then go through to pin 8. If, however, pin 13 is earthed, pins 11 and 9 become high, allowing signals on pin 2 (the spare input), to go through to pin 8, and thence to the 7216B pin 28.

Using a two-pole, three-position slide switch enables this switching function to be linked with an on/off supply switch.

The prescaler drops in performance on, and below 5V, and as the other i.c.s will happily accept a *slightly* higher voltage, the regulator incorporates a silicon diode 1N4001 in the common line. 0·6 volts are dropped across this diode, so the common pin is held at 0·6 volts above zero. The output is regulated at 5V above the common pin, so the output regulated voltage becomes 5·6V.

CONSTRUCTION

This obviously demands care and patience, but is well within the scope of most constructors. The most awkward part of the project is the interwiring of the displays (necessary because the digit outputs are multiplexed). FND357 is the code number of the displays used, and they are approximately 13mm high, containing 10 pins, see Fig. 5 (top left).

The author used normal stripboard, but this involved much track cutting, including breaks between adjacent holes? If the p.c.b. is not used it may well be easier to use plain perforated board, and attach the displays with tiny blobs of glue. The digits would then be wired in parallel, A-A, B-B, etc., except the digit drivers (the common cathode pins), which are connected to the driver terminals D0 to D7, (D0 being the right-hand digit, looking at the display from the front). NB: D1 and D2 are not in order on the i.c. A piece of black plastic was cut to fit behind the aperture in the case, and after a hole was cut in this piece to accept the display (a tight push fit), it was glued behind the aperture. *Very* short lengths of wire were used to connect the display segments and the digit drivers to the p.c.b. (see wiring diagram Fig. 12). Slide switches (RS code 337-481) and two BNC sockets were inserted, the switches being attached with glue. Wires were then taken from the D1, D2, and D3 terminals (5,6,7), and connected to one of the slide switches, with the wiper going to the resistor connected to pin 14. This provides the three gate times. The other switch is wired as already shown in Fig. 12 to provide an on/off and input changing.

One BNC is connected to pin 2 of IC2, and the other BNC is connected to the input of the prescaler, using miniature coaxial cable. Connections are taken from the prescaler board for the output, positive and zero to the main board. Make sure that the shields of the BNCs are also connected to zero volts. Depending on where the prescaler board is sited, take care that it does not short on any metal of the battery case, the switches, or the sockets.

ADJUSTMENTS

Measure the output voltage of the regulator to ensure that it is 5·6V. Adjust the preset on the prescaler board to give half this voltage on the collector of TR1.

The oscillator needs to be adjusted by means of the trimmer to 10MHz using a reference of some sort. The accuracy of the meter depends on this calibration, and the tolerance of the quartz crystal. VC1 may need to be 65pF.

CONCLUSION

The prototype triggered from a portable rig (one watt) a few feet away, with only a short piece of wire pushed into the BNC socket, and has provided the author with a valuable piece of portable test equipment, registering frequencies up to 220MHz. Some spare pads have been provided should constructors wish to add extras (as well as those mentioned earlier), if they can find the space! Some suggestions are given below.

1) If pin 13 is temporarily connected, via a pushbutton, to earth, the counter will reset.

2) Pin 1 is the control input, and using IN914 diodes as per Fig 7 digit driver pins can be connected to provide the following amongst others:

a) D0 . . . and external oscillator can be fed in

b) D1 a 1MHz crystal can be used, using the same multiplex rate

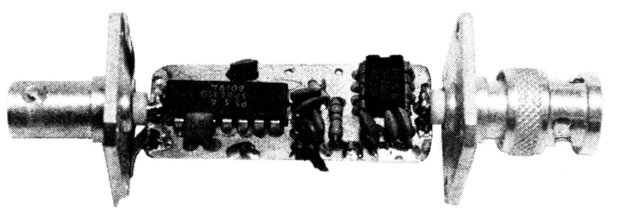
c) D3 blanks the display, in conjunction with the hold button, see below

d) D7 will test the display, lighting all segments

3) If pin 27, normally held low by the resistor, is temporarily connected to +ve the display will hold. If done in conjunction with D3 to pin 1, the display will blank.

4) If an l.e.d. is connected between pin 23 and ground, it acts as an overflow indicator (see Fig. 6).

600MHz OPTIONAL PRESCALER



THIS can be built either as illustrated, i.e an external module housed in a module case (RS 456–201) drawing its supply from two 1mm sockets inserted in the side of the frequency meter case; or as a replacement board for the 200MHz prescaler. Both prescalers will in fact work down to dc level, but below certain frequencies the i.c.s become dependent on the slew rate of the incoming waveforms. The divide-by-ten SP8630 will operate down to 40MHz with a sinusoidal input. The prototype triggered quite happily from the 12MHz oscillator stage of a transmitter using a "sniffer probe" (coaxial cable terminated with two or three turns of 20 SWG wire).

The SP8630 needs to be handled with care, because a negative earth plane is being used and consequently its emitter-follower outputs are liable to damage if shorted to ground, so check the p.c.b. and wiring before inserting the SP8630 and switching on. The output is fed into another divide-by-ten, the much cheaper SP8660 (but which will work at such high frequencies as the SP8630), which provides a TTL compatible output, which goes into the 74LS132 and thence into the counter.

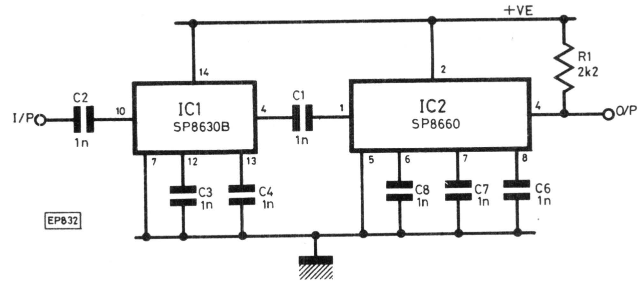


Fig. 13. External/optional prescaler circuit diagram

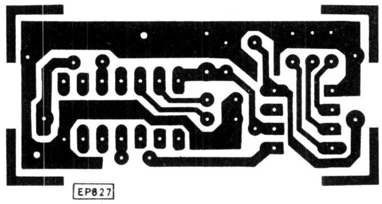


Fig. 14. External/optional prescaler p.c.b. track layout

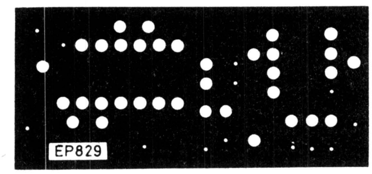


Fig. 15. Component side copper earth plane

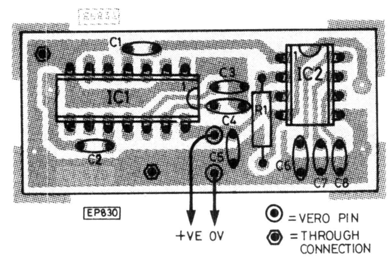


Fig. 16. Component layout

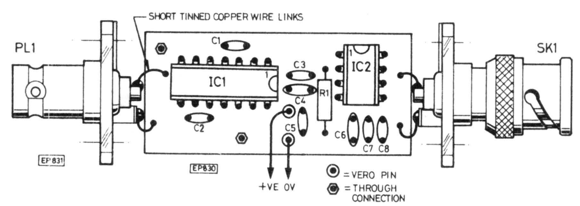


Fig. 17. Connection to BNC connectors

Constructors will no doubt have noticed that there is no preamplifier in the design. This was for two reasons. A preamplifier was designed using a BF180, but to use it precluded the use of the module case, which is an extremely convenient size.

Experiments were then carried out using the prescalers alone, and it was found that using a small pick-up aerial (six inches of wire!) the meter triggered from a 432MHz transmitter feeding 500mW into a helical aerial four feet away. It was felt by the author that this was sensitive enough for most practical purposes. However, it needs to be stated that the input drive level requirements do vary, needing e.g. approximately 80mV peak-to-peak sine wave at 432MHz, but approximately 140mV at 145MHz. The prototype triggered from a 1 watt 145MHz transmitter 6 feet away with ease. For more information constructors are advised to consult the Plessey data contained in their publication *Digital Integrated Circuit Data Book*, and if necessary build a preamplifier from the many designs available, knowing that a bigger case will have to be used.

The second reason is that the battery drain, already high, would have been unacceptable had a preamplifier been included in the circuit.

CONSTRUCTION

It has been stated from the outset that constructors have a clear choice whether to build this prescaler into the meter, or as an external module. The former method is simply a matter of filling the 200MHz space with the 600MHz board, using the same supply and input/output leads. The meter will then still have a spare input. To use the prescaler externally, the RS module box has first to be slightly modified. Cut back the centre contacts of the sockets inside the box as far as possible, and drill a small hole in the side of the box, through which the supply leads can be fed.

The project uses a double sided printed circuit board, the component side being used as an earth plane, and if constructors attempt their own, it is not difficult. Prepare the track side as normal, using an etch resist pen or transfers, and then cover the reverse side with either etch resist or, as the author does, with insulating tape, using a slightly oversized board, and folding the tape slightly over the edges to prevent seepage of the Ferric Chloride. After etching, cut and file the board down to size, and drill the holes out as normal. Then from the component side countersink all non-earth holes, hand-twisting a $\frac{1}{8}$inch drill bit, or using a Veroboard cutter. The author also drilled three or four holes through the board where there was earth both sides to ensure the earth planes were connected together to counteract possible capacitance problems.

The components are then mounted close to the board (without shorting the earth-plane) and components going to earth are soldered both sides. It is always a wise policy to use double-sided board at these sorts of frequencies, but the author did make a single sided board, using exactly the same design minus the earth-plane, and it did work as an external module, but this may be a fluke of the particular i.c.s and *may* not be repeatable.

Two pieces of copper wire were inserted into the input and output positions on the board, and these were soldered direct to the centre contacts, thus suspending the board inside the case. This ensured that the board did not short out on the metal case. The case earth contacts were then bent over and soldered direct to the board, and the supply leads were fed through the drilled hole. Refer to Fig. 17 which should make the explanation clearer. After a careful check replace the removable side of the case and bolt the module together.

COMPONENTS . . .

Resistors

R1	2k2

Capacitors

C1–C8	1n (8 off)

Integrated Circuits

IC1	SP8630B
IC2	SP8660

Miscellaneous

Printed circuit board
BNC plug and socket

Two 1mm sockets need to be inserted into the side of the frequency meter case, one connected to earth, the other to the output of the voltage regulator (5V6). Two 1mm plugs are connected to the supply leads of the prescaler module. The INT/EXT switch should be set to EXT, the module connected to the EXT BNC socket and a small pickup aerial attached. The author cannibalised a small transistor radio telescopic aerial (about 6 inch, long unextended), and soldered it to the centre of a BNC plug. Epoxy resin sealed the unit and prevented the aerial from shorting on the BNC plug case. The meter should then read frequencies up to 600MHz.

If constructors are irritated by the display counting randomly, caused by the SP8630 and the SP8660 self oscillating, a cure can easily be effected using the following procedure: (however this will cause a *slight* loss of sensitivity). Solder a 15k resistor between the input, pin 10 of the SP8630, and earth (on the track side if necessary), and a 39k resistor between pin 8 of the SP8660 and earth.

CONCLUSION

It is hoped that this article will enable constructors to build what has proved to the author to be a very useful piece of portable test equipment, e.g. for testing portable rigs, radio control transmitters (27MHz, 35MHz, and UHF) at a price and performance to beat most commercial units. ★

BAZAAR

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NEXT MONTH

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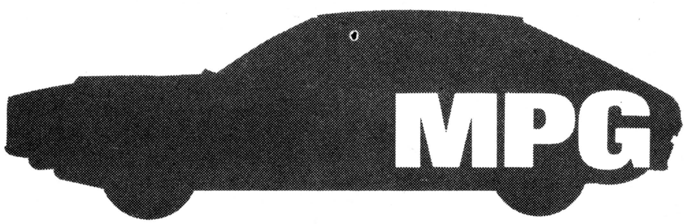
Microsynth



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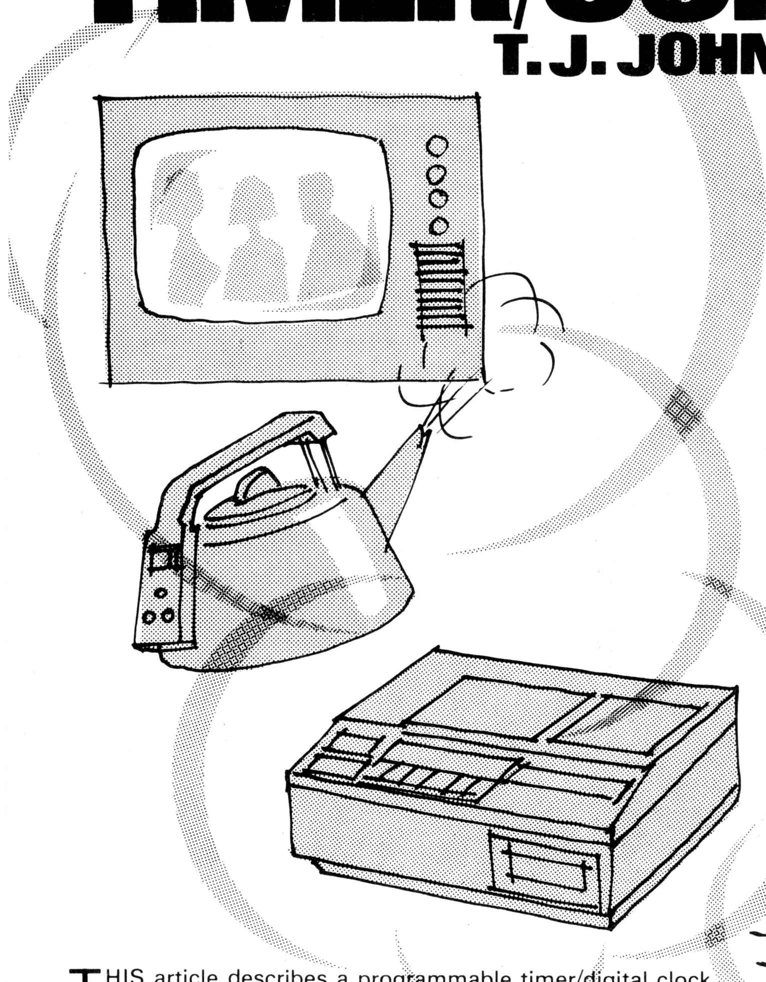
PROGRAMMABLE TIMER/CONTROLLER

T. J. JOHNSON

PART ONE



THIS article describes a programmable timer/digital clock which has the ability to control mains operated appliances. Basically the unit consists of a conventional digital clock which displays the time of day in the 12 hour format, either AM or PM and also the day of the week.

The timer/controller section (actually part of the same i.c. used by the clock), is a specially mask-programmed four-bit single chip micro-computer which provides the dedicated function of a time of day and day of week controller. The system provides a total of 18 "timer sets" which can control any one of four mains operated switches independently. Programming the system is very simple using a 20 key keyboard.

THE TMS1121NLL I.C.

The basis of the system is the TMS1121NLL i.c. This is housed in a 28 pin package and details of the device are shown in Fig. 1. As mentioned above, this is a dedicated i.c. and has the following important features.

CLOCK OPERATION

Operation as a clock follows conventional lines displaying the time in the usual 12 hour format, with separate l.e.d.s. to indicate whether it is AM or PM, and also the day of the week (Sunday to Saturday). The time and day are initially set via the keyboard, and once in operation depends on the accuracy of the mains 50Hz frequency for its overall accuracy.

TIMER/CONTROLLER

Used as a programmable timer controller, the i.c. can retain in its memory up to 18 separate pre-programmed "timer sets", which are entered via the keyboard. Each timer set can control one of four switches, which in turn control an external appliance. Only two states are possible, either on or off.

The timer sets can be placed into three modes:

1. *Fixed Time Programs,* which will turn on or off a particular switch at a particular time.
2. *Interval Programs,* which will turn on or off a particular switch after a specific time interval has elapsed from the time the program was entered.

Once executed, an interval program is erased from the memory, thus these types of programs can only be executed once. Fixed time programs however, are retained in the memory and are executed repeatedly.

3. *Sleep Programs.* A special function on the keyboard is the SLP (sleep) key. If this key is used after an interval program, then that switch to which it applies is turned on immediately and then turned off exactly one hour later. Using this function a valuable timer set can be saved for some other application.

OTHER FUNCTIONS

The i.c. via the keyboard can provide direct operation of any of the switches without programming that function into the memory. Thus any switch can be turned on or off independently of any program relating to that switch—a particularly useful function.

The timer *sets* can be changed at any time by either selectively erasing the *sets* which relate to a particular switch or to a particular day, or by erasing all the *sets* and starting fresh with a clear memory.

Finally, any program in the memory can be recalled using the keyboard, the state of the program being displayed by l.e.d.s. The standard four digit clock display is used to show the time at which the switch is to be turned on or off, while various other l.e.d.s. indicate the day of the week, the switch number, either AM or PM and whether the switch will be on or off at that time.

CIRCUIT DESCRIPTION

The complete circuit for the Programmable Timer/Controller is shown in Fig. 2.

The circuit requires two voltages which are obtained from the mains power supply. The first supply is obtained by rectifying the a.c. output from the 9V mains transformer to give about 12V d.c. This is used for the display segments and also the l.e.d.s.

The second supply uses an 8V regulator to provide a stable and fully regulated output of 9V. The precise voltage may be varied by using the preset VR1. This supply is used to power the main i.c. and the interface i.c., IC3. As well as providing the two voltages the mains transformer also supplies a source of 50Hz, which is used as the standard clock signal for the microprocessor IC2.

The i.c. operates at a frequency of approximately 300kHz, this frequency being set by the values of C7 and R3. The 50Hz clock signal from the mains transformer is applied via TR1, which roughly squares the sine wave, to the input at pin 8. Transistor, TR2 and associated components, use the 50Hz signal to provide a short pulse which is used to reset the internal circuits and to clear all information in the memory when the timer is first switched on.

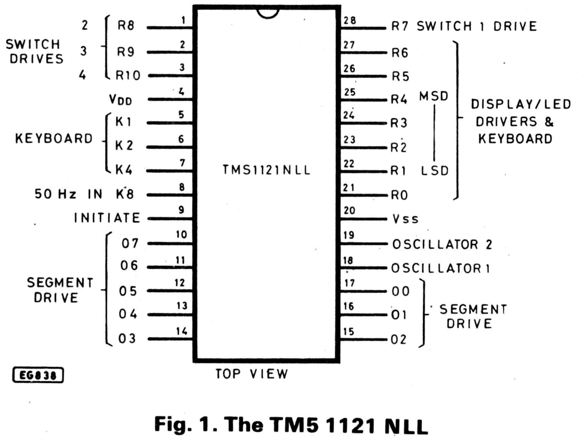


Fig. 1. The TM5 1121 NLL

KEYBOARD

Information to be programmed into the i.c. is input via the keyboard of which a few of the keys have double functions, for example the E DAY/0 key is the numeral "0", and the events key to program what happens on each of the seven days of the week.

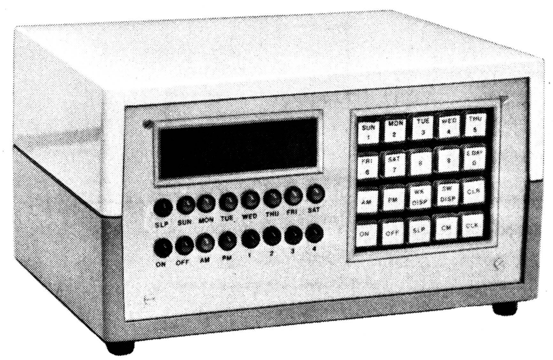
The switch numbers and their functions (and also the front panel labelling) are shown in Table 1.

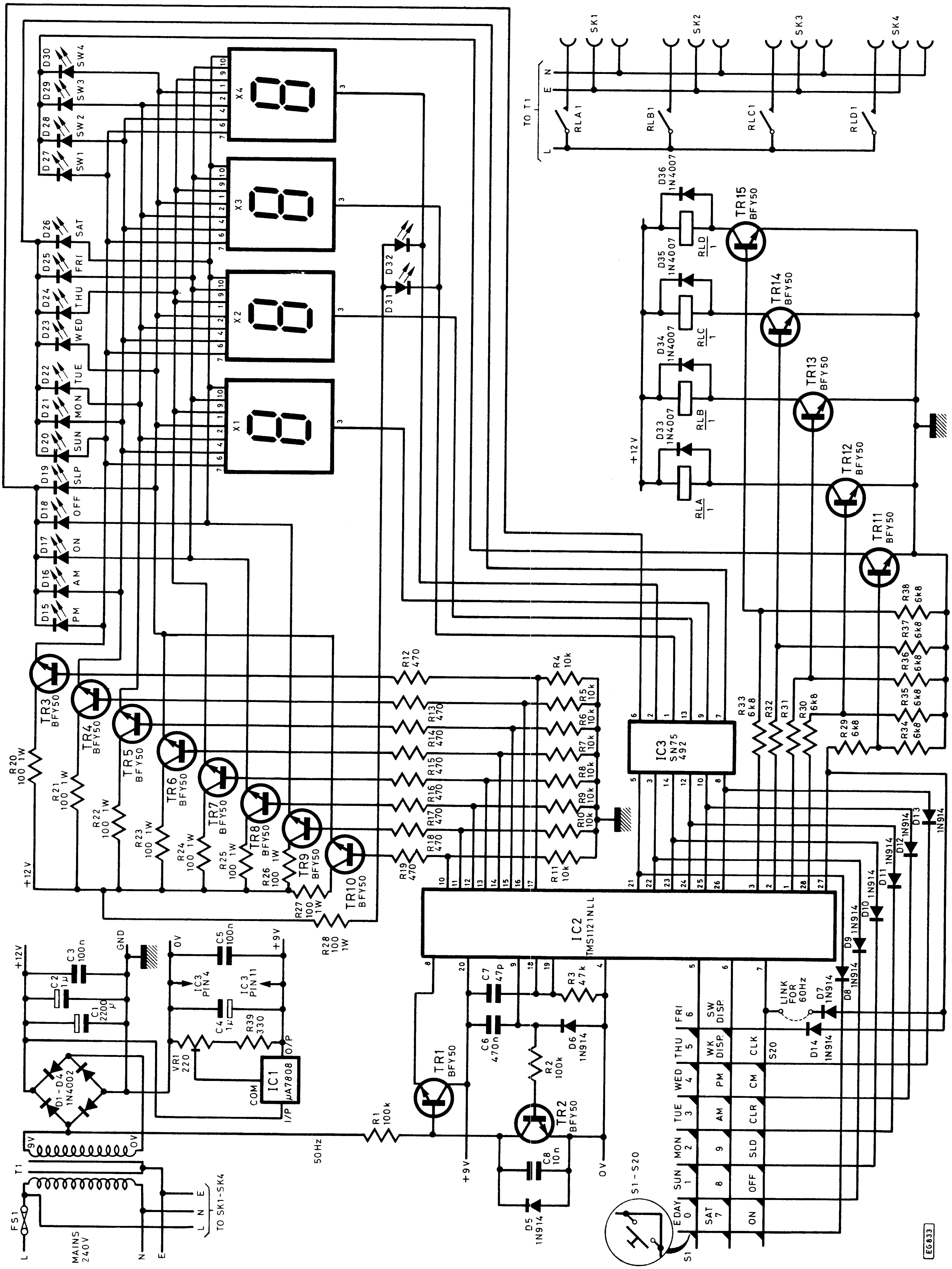
SWITCHES

The circuit provides for turning four relays on or off, via TR12 to TR15 and their associated resistors. Obviously, other output devices may be used, s.c.r.s. for example could be driven by the transistors, but for simplicity and maintenance free operation, relays would appear to be the most appropriate choice. The outputs from the relays are connected to four mains sockets.

Switch number	Function	Labelling (for front panel)
1	Everyday or numeral 0	E DAY 0
2	Sunday or numeral 1	SUN 1
3	Monday or numeral 2	MON 2
4	Tuesday or numeral 3	TUE 3
5	Wednesday or numeral 4	WED 4
6	Thursday or numeral 5	THU 5
7	Friday or numeral 6	FRI 6
8	Saturday or numeral 7	SAT 7
9	Numeral 8	8
10	Numeral 9	9
11	AM setting	AM
12	PM setting	PM
13	Set day of week or display day of week. (Press twice to display).	WK DISP
14	Set switch number or display switch (Press twice to display).	SW DISP
15	Set switch ON	ON
16	Set switch OFF	OFF
17	Set SLEEP function	SLP
18	Clear last entry or correct error	CLR
19	Clear all programs from memory	CM
20	Start clock (only used when changing time setting on clock).	CLK

Table 1. Switch numbering and their functions




SK1
SK2
SK3
SK4
TO T1
RLA1
RLB1
RLC1
RLD1
D36 1N4007
D35 1N4007
D34 1N4007
D33 1N4007
+12V
RLA
RLB
RLC
RLD
TR11 BFY50
TR12 BFY50
TR13 BFY50
TR14 BFY50
TR15 BFY50
X1
X2
X3
X4
D31
D32
D15 PM
D16 AM
D17 ON
D18 OFF
D19 SLP
D20 SUN
D21 MON
D22 TUE
D23 WED
D24 THU
D25 FRI
D26 SAT
D27 SW1
D28 SW2
D29 SW3
D30 SW4
TR3 BFY50
TR4 BFY50
TR5 BFY50
TR6 BFY50
TR7 BFY50
TR8 BFY50
TR9 BFY50
TR10 BFY50
IC3 SN75 492
IC2 TMS1121NLL
R28 100 1W
GND
0V
+9V
IC3 PIN4
IC3 PIN11
C3 100n
C2 1µ
C1 2200µ
C5 100n
C4 1µ
R39 330
VR1 220
IC1 µA7808
COM
I/P
O/P
D1-D4 1N4002
T1
9V
FS1
MAINS 240V
TO SK1-SK4
50Hz
R1 100k
TR1 BFY50
TR2 BFY50
C7 47p
C6 470n
R3 47k
R2 100k
D6 1N914
C8 10n
D5 1N914
S1-S20
S1
LINK FOR 60Hz
S20
E6833

COMPONENTS . . .

Resistors

R1, R2	100k (2 off)
R3	47k
R4–R11	10k (8 off)
R12–R19	470 (8 off)
R20–R28	100 1W (9 off)
R29–R38	6k8 (10 off)
R39	330

VR1 220 hor. preset
All ¼W 5% except where stated

Capacitors

C1	2200µ 25V elect
C2	1µ 63V elect.
C3, C5	100n polyester (2 off)
C4	1µ 63V elect.
C6	470n polyester
C7	47pF polystyrene or ceramic plate
C8	10n polyester

Semiconductors

D1–D4	IN4002 (4 off)
D5–D14	IN914 (10 off)
D15, D18	0·2in l.e.d. green (2 off)
D16, D20–D26	0·2in l.e.d. yellow (8 off)
D17, D19, D27–D30	0·2in l.e.d. red (6 off)
D31, D32	0·125 in l.e.d. red (2 off)
D33–D36	IN4007 (4 off)
TR1–TR15	BFY 50 (15 off)
IC1	µA 7808
IC2	TMS 1121 NLL
IC3	SN 75492
X1–X4	0·6" 7 segment display red. TIL322 or FND500 (4 off)

Switches

S1–S20 miniature keyboard switch with removable cap. (Ambit type ref. KHC10901—switch, two part cap type KT5 ref. 53-90901).

Relays

RLA–D OUD type, s.p.d.t. contact, 12V 400 ohm coil. (Maplin type ref. YX97F). Other types with a similar coil may be used, but may not fit the p.c.b.

Miscellaneous

T1 9V 1A mains transformer
SK1–4 "Euro" type 3 pin mains socket rated at 240V 6A.
Heatsink for IC1
Small mounting brackets (4 off)
6BA hardware
I.c. sockets if required, FS1 13A fuse and fuseholder
Three p.c.b.s
Verobox type 21036G 205×140×110mm
Piece of red perspex
Plastic trim
Mains cable connecting wire etc

DISPLAY INTERFACE

The hours/minutes display uses four 7-segment displays which are multiplexed, the segments being driven via TR3-TR9 and associated resistors R12-R18 and R4-R10. Current limiting of the segments is provided by resistors R20-R26, and as they are multiplexed the average segment current is 10mA.

The multiplexed drive for each of the four displays is provided by the interface i.c., IC3. This is a special MOS to l.e.d. digit driver, and is required to provide the necessary interface between the very low level MOS output from the i.c. to the high current drive requirements of the displays.

The remaining three outputs of the i.c. are used to drive the indicating l.e.d.s D15-D30. These l.e.d.s are also multiplexed and share the drive on the segment lines.

The clock normally operates at 50Hz, however, if it is to be used where the mains frequency is 60Hz, then the link indicated must be fitted.

CONSTRUCTION

Construction is quite straight forward, the vast majority of the components being mounted on three printed circuit boards. The type of housing used for the project was chosen because it was the most practical type to use, some constructors may like to house the project in a more aesthetically pleasing case, with just say, the four digit display on the front panel and perhaps the keyboard mounted on the top or side. It should be quite easy to split the display/keyboard p.c.b. in two and mount each in a suitable position.

Personal preference also applies to the choice of output connectors, obviously a universal method of connecting the appliances to the unit was required. The first choice was conventional 3 pin flat sockets, however this would have made the dimensions of the case rather large. The second choice was to connect the various appliances directly and permanently to the unit. This would have meant that the unit could not be used with additional appliances without considerable work to change each one over. Of course this direct method can be used where it is envisaged that future changes are not required.

They system adopted was the use of "Euro" type sockets as shown. Each mating plug was connected to an appropriate length of three core mains cable, the opposite end being fitted with a rubber line socket, the type found on electric drill extension leads. The length of each lead will of course depend on the distance of the unit from each appliance, so a central position should be chosen and the length of each lead adjusted accordingly. All of the four leads need not be made up at the same time each one being wired up when they are required.

PRINTED CIRCUIT BOARDS

There are three p.c.b.s; the display/keyboard, main logic and driver board, and the power/relay board.

The p.c.b. design for the display keyboard is shown in Fig. 3 with the component layout shown in Fig. 4. The key switches can be mounted first, remember that only the types specified will fit onto the board. They may be orientated either way. The four 7-segment displays and the two l.e.d.s. which fit between two of the displays can be mounted next. Do not mount the remaining l.e.d.s. at this stage, they will be fitted later.

The design and component layout for the logic/driver board are shown in Figs. 5 & 6. A socket is advised when mounting the main i.c. and the interface i.c. For neatness the transistors were mounted on nylon mounting pads, although this is not essential. The 1W resistors should be mounted just above the p.c.b. as they get slightly warm in operation.

If the system is to be used on 60Hz mains operation then the link indicated should be wired in, it should be left unconnected when used on 50Hz.

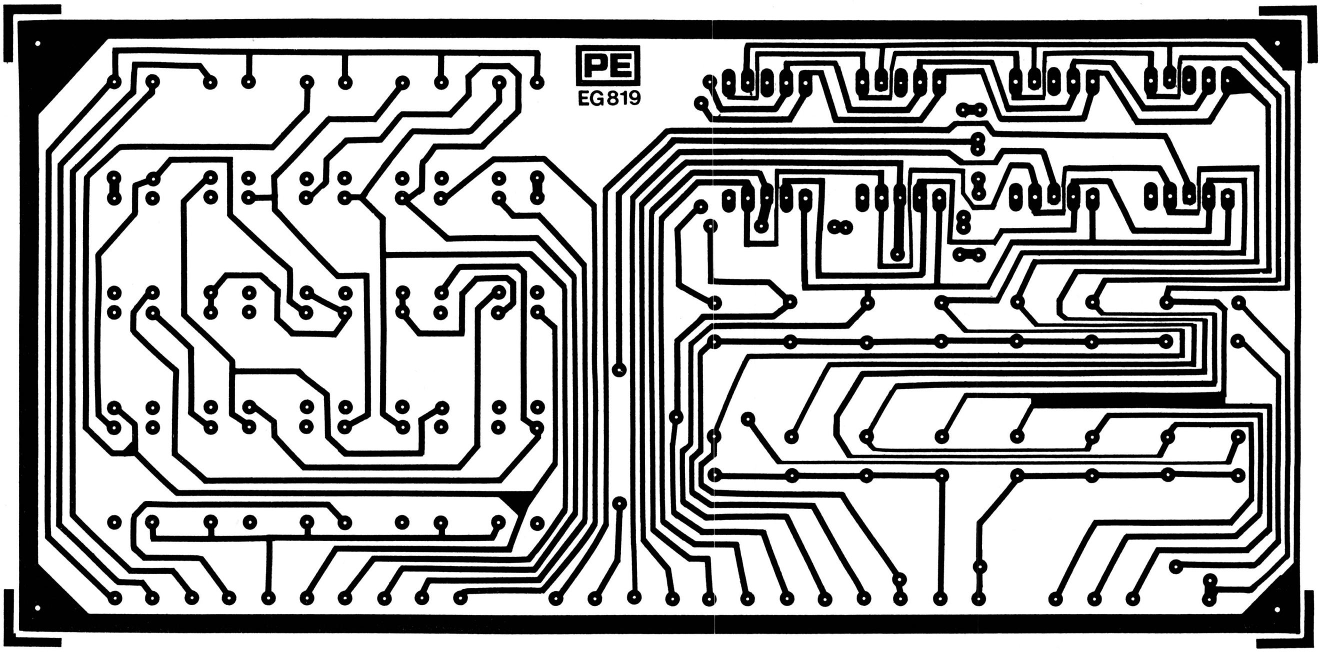


Fig. 3. P.c.b. design for the display keyboard

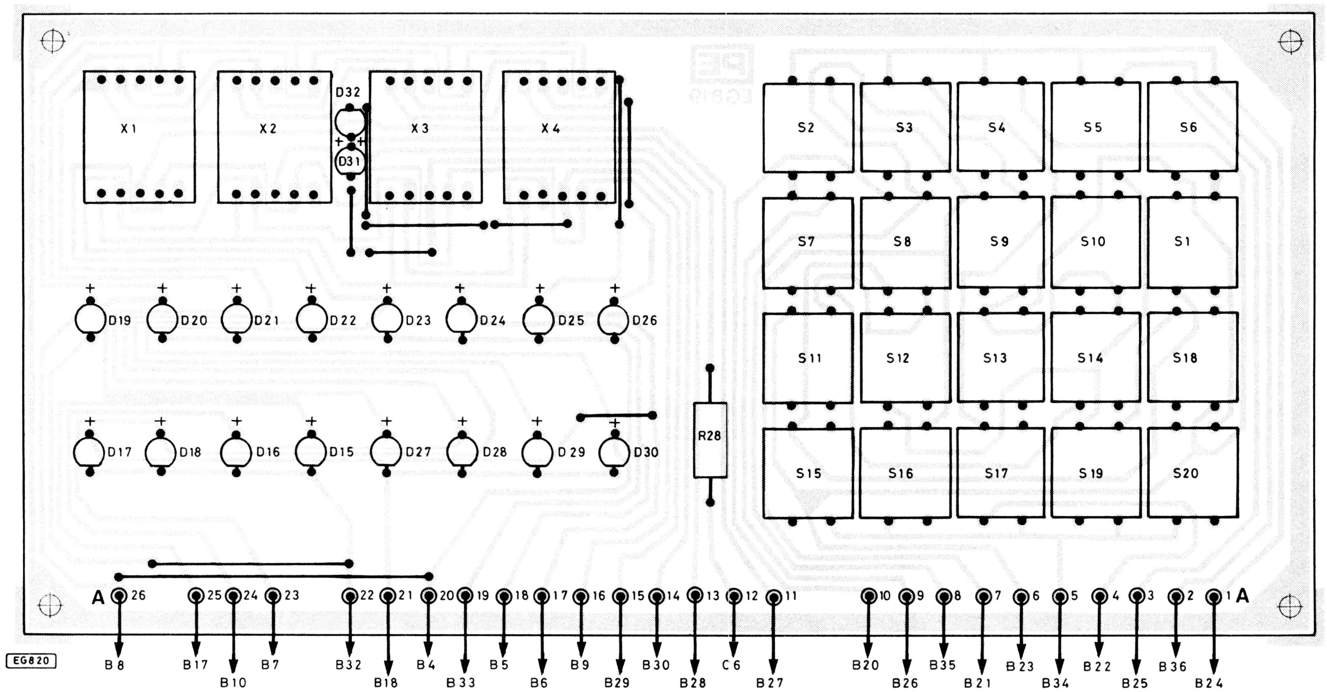


Fig. 4. Component layout

The power supply/relay board is the last to be completed and the design and component layout are shown in Figs. 7 & 8.

DRILLING DETAILS

Cuttting details for the front panel are shown in Fig. 9. These dimensions are exact and should not need variation. The two large cutouts were finished off with lengths of special plastic edging, although a similar effect can be achieved with p.v.c. sleeving. A piece of red perspex was glued in place as shown on the photographs.

Standard two piece plastic l.e.d. clips were pushed into each of the holes but the retaining rings were not fitted at this stage.

The cutting details for the rear panel are shown in Fig. 10. The sockets are a push fit so the cut-outs should be as accurate as possible and can even be a little undersize.

The key switches come with a two part cap, and lettering can either be applied to the bottom half directly, or on small squares of white paper.

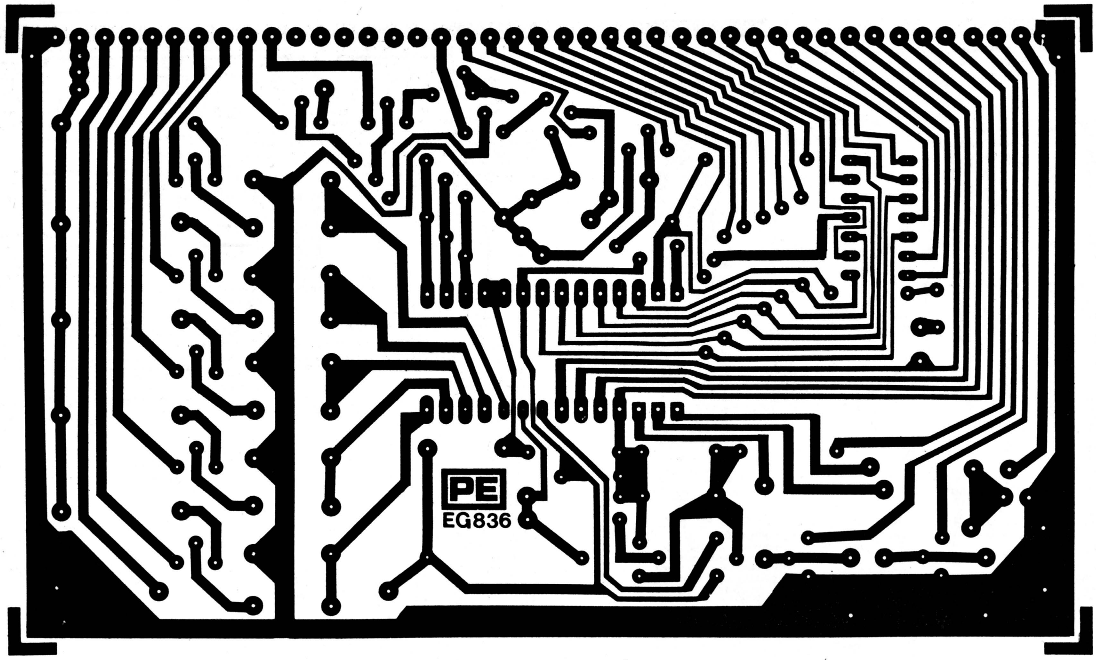


Fig. 5. P.c.b. design for the logic driver board

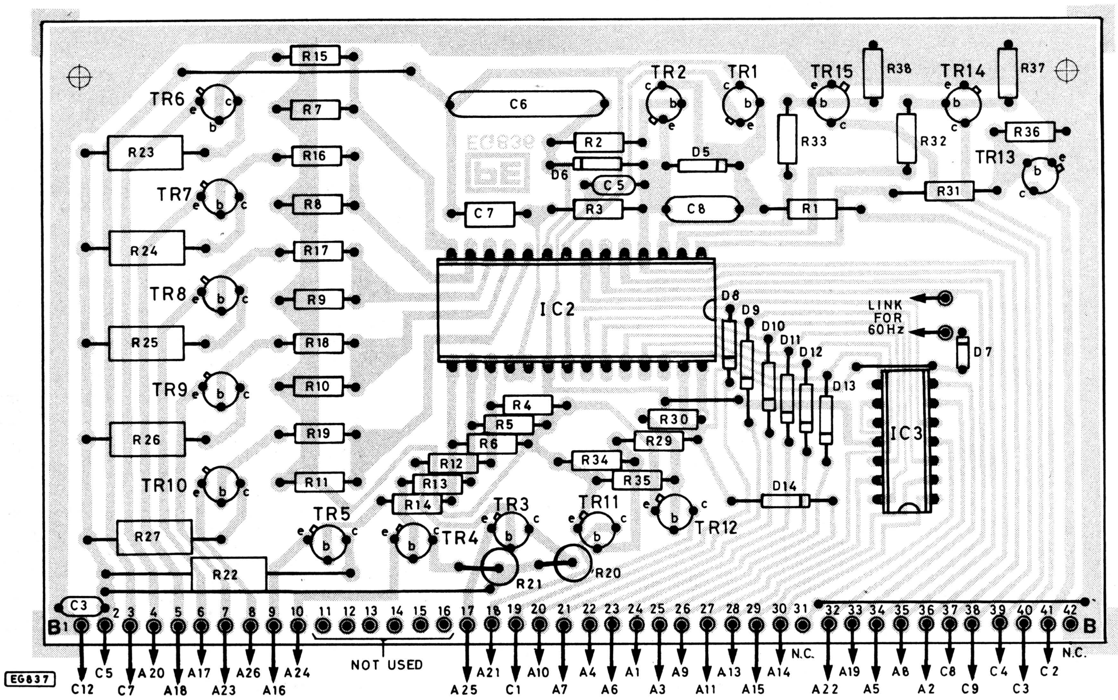


Fig. 6. Component layout

FINAL WIRING

The display/keyboard p.c.b. should first be mounted on the front panel. Before doing so, connect all the flying leads to the board. Each wire can be about 6-8" in length, ribbon cable can be used here, but note that each connection on the display board is not in sequence with the same connection on the logic board.

Next mount all the l.e.d.s. into their panel clips and push the locking rings over each clip. Note we are using three different coloured l.e.d.s. so be sure to insert each into their correct place. Two methods can now be used to connect the l.e.d.s to their respective connection on the p.c.b. Either use short lengths of connecting wire, say 2", and connect each lead of the l.e.d.s to the p.c.b., or, as in the prototype push the leads of the l.e.d.s. directly into the correct holes. If this method is used then the leads will need to be splayed out slightly. This operation is quite difficult and inexperienced constructors should use the first method.

Finally, using spacers and countersunk screws the p.c.b. can be permanently fitted into position.

The mains outlet sockets can now be mounted on the rear panel, if they seem a little loose then they may be fitted in

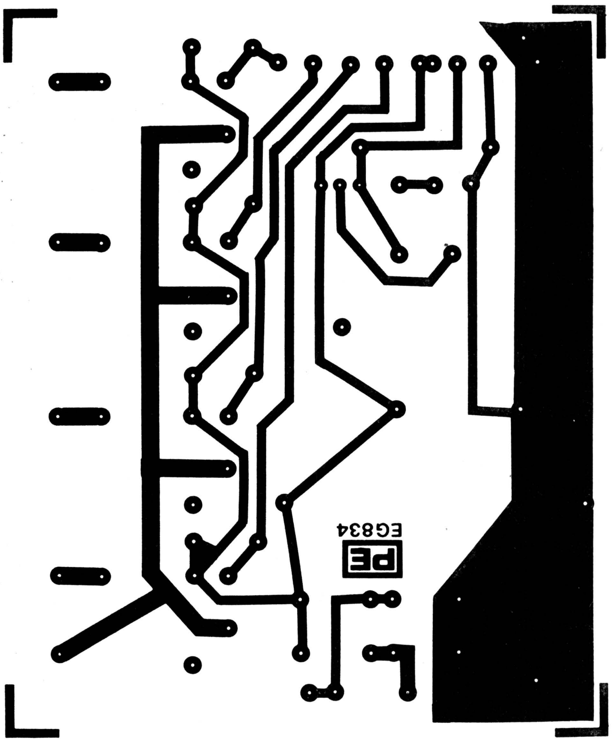


Fig. 7. P.c.b. design for the p.s.u.

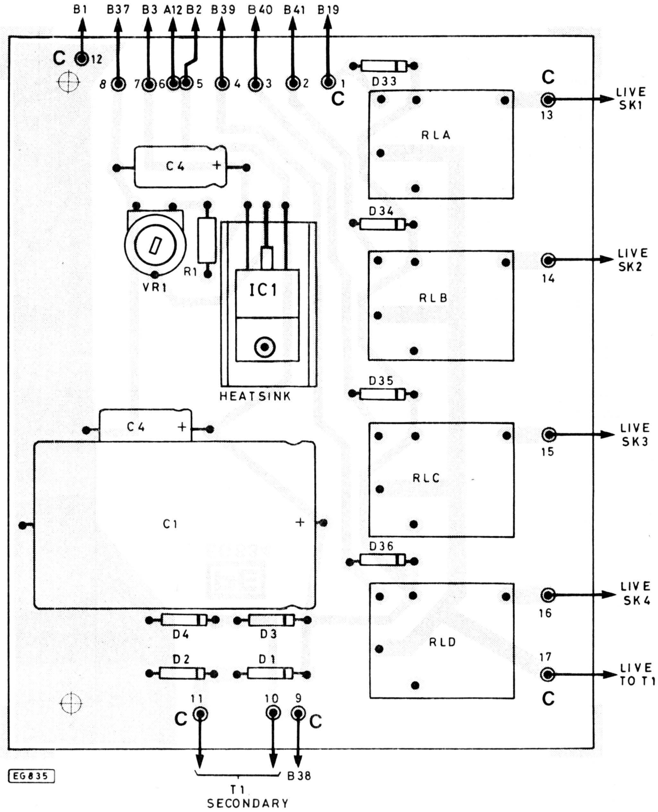


Fig. 8. Component layout

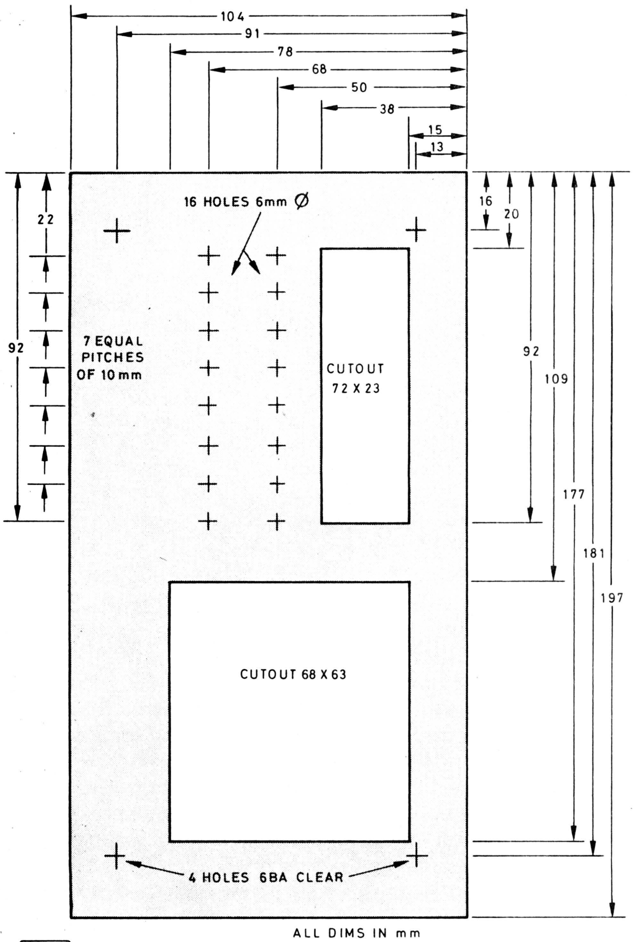


Fig. 9. Cutting details for the front panel

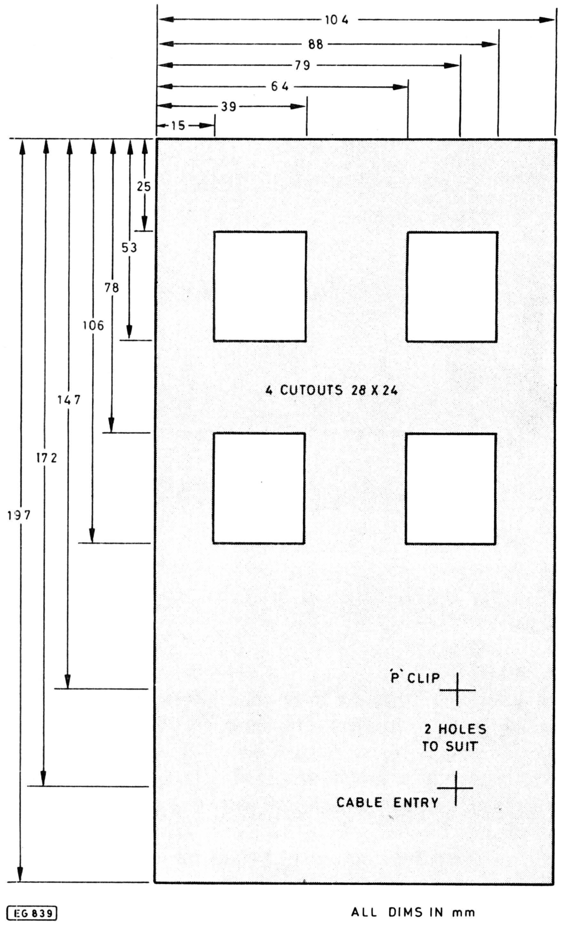


Fig. 10. Cutting details for the rear panel

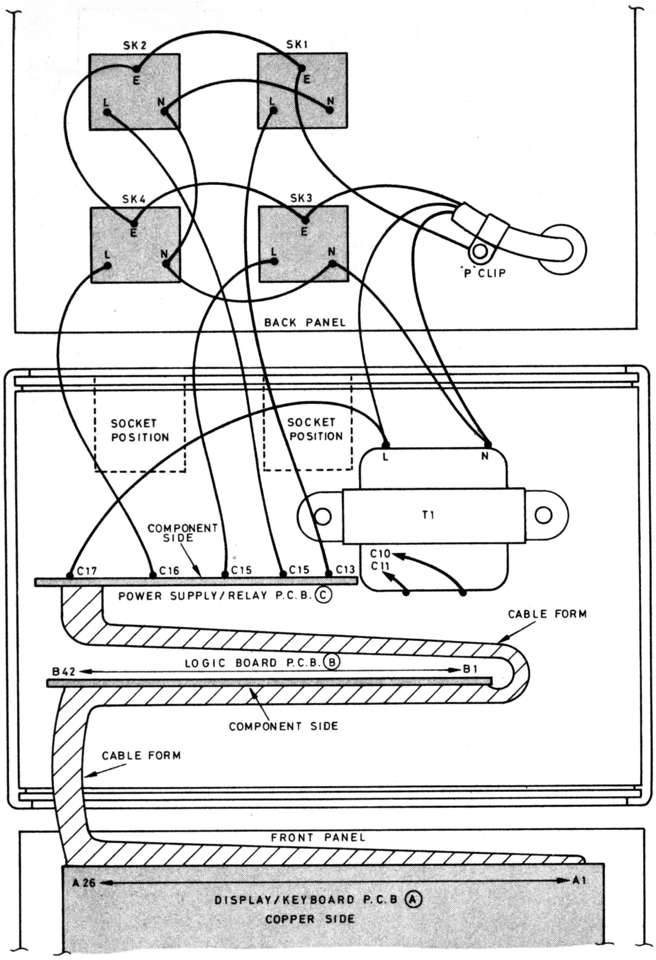
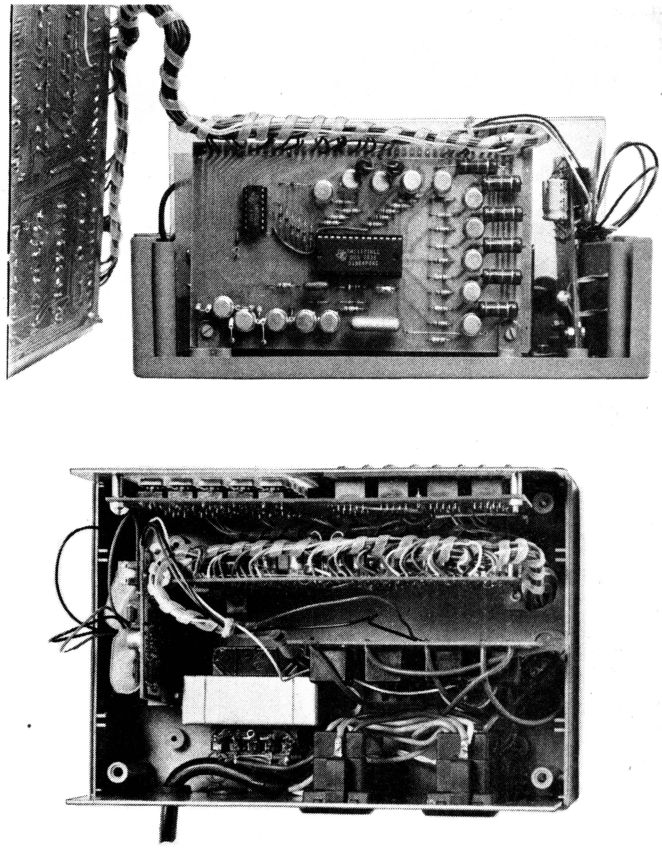
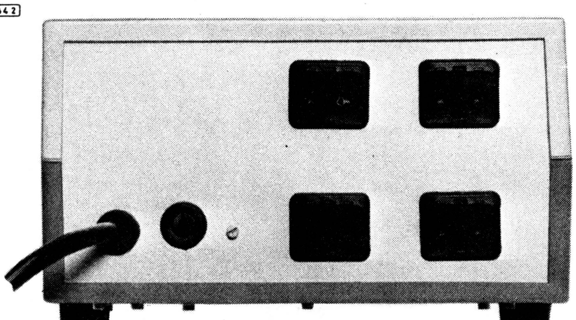


Fig. 11. Wiring diagram

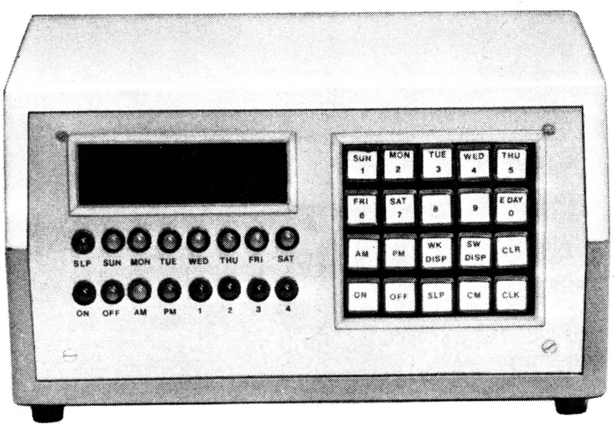
EG 842



Internal views



Rear panel



Front panel layout

place with a strong adhesive if required. The remaining two p.c.b.s. can be mounted in positions as dictated by the dimensions of the transformer. Small right-angled brackets can be used to mount the boards.

Finally, the remaining wiring shown in Fig. 11. can be completed.

TESTING

Before connecting the unit to the mains, the p.c.b.s. should be checked for errors, solder splashes, bridged tracks etc. If all seems well, temporarily remove the leads going to the 12V and 9V connections on the power supply board. Connect the unit to the mains supply. BE VERY CAREFUL when working on the power supply/relay board, it carries mains voltage as soon as the mains supply is connected.

With a voltmeter check the 12V supply, it should within reason, be 12·5V, anything greater than this there is most likely a fault and should be rectified before continuing. Next measure the 9V supply and adjust the preset to obtain precisely 9V. Do this as accurately as possible, as the main i.c. is rather critical about the voltage applied to it.

If all is well, reconnect the two supply leads, switching off the mains supply first of course. Next reconnect the mains supply and observe that the display illuminates and shows 12:00, with the PM and Sunday l.e.d.s. lit only when the CLK key is pressed. If the unit is connected to 60Hz mains frequency then the display will show real time and continue to change as each minute passes.

There are no further tests to be made, and the unit can be left connected to the mains to insure that no component overheats. The large 1W resistors will of course get warm but should be of no concern.

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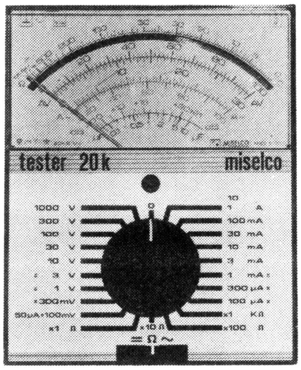

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d.c. I 50μA, 100μA, 300μA, 1.0mA, 3mA, 10mA, 30mA, 100mA, 1A, 10A. a.c. V 10V, 30V, 100V, 300V, 1000V.
a.c. I 3mA, 10mA, 30mA, 100mA, 1.0A, 10A.
Ω 0–5.0kΩ, 0–50kΩ, 0–500kΩ, 5MΩ, 50MΩ.
dB from −10 to +61 in 5 ranges.
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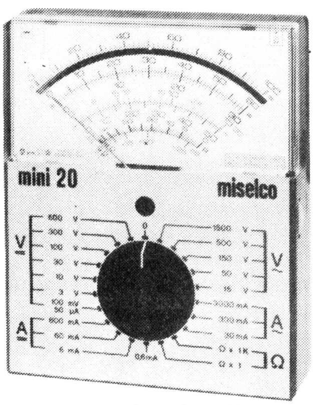

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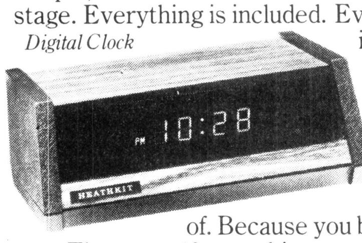

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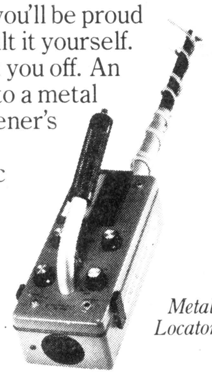
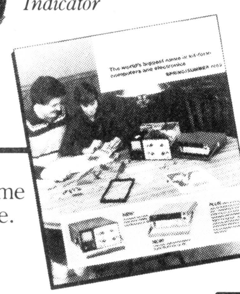


Metal Locator

Windspeed and Direction Indicator



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IEEE-488/IEC-625 INTERFACE BUS & Automatic Test Equipment...

By D. Mandelzweig

INTERESTED in microcomputers for business and at home? Would you like to expand your system, easily, with a truly standard bus? Do you take tedious measurements? Then maybe the IEEE-488 bus and its applications which is the subject of this supplement will interest you. Even if you do not own or use a mini- or microcomputer, but are interested in test instrumentation and Automatic Test Equipment (ATE) and its uses, read on.

MICROCOMPUTERS are already in widespread use insmall businesses, keeping full control of accounts, debtors, creditors, stock etc. However, few people are aware of the tremendous capabilities these computers have in the electronic workshop, especially in small companies where items are manufactured and have to be tested, or where repetitive test work is to be done.

For the amateur at home, the IEEE 488 bus allows easy interfacing of sophisticated (if required!) devices for the home computer. Not only sophisticated devices, but also printers, plotters, floppies and hard disks. Readily available LSI IC's are available with full application notes, allowjng the experimenter to interface anything he desires with his own computer.

It is the intention of this supplement to give an insight into small and large scale automatic testing, a glimpse of what 488-bus devices are available, and an introduction to the mode of operation of the bus, according to the standard.

INTRODUCTION AND HISTORY

The IEEE-488 INSTRUMENTATION BUS (called the 488-bus or just the bus in the rest of this feature) was originally designed and developed by Hewlett Packard (HP), who still hold world wide patent rights on the bus. It was designed by them "to provide an effective communication link over which messages are carried in an unambiguous way among a group of interconnected devices" (Ref 1). The method uses a 3-wire handshake to transmit bit-parallel, byte-serial data, which can be divided into two broad categories, viz:

(i) messages used to control the interface system itself, referred to as interface messages, and

(ii) messages used by the devices connected to the bus, referred to as device dependant messages.

In 1975 the IEEE adopted this HPIB (Hewlett Packard Interface Bus, or GPIB—General Purpose Interface Bus by which it is also well known) as a standard for bit-parallel, byte-serial data transmission, mainly intended for use in instrumentation systems. In 1978 the standard was slightly improved, and was rewritten to make it more understandable. The standard has an international counterpart, the IEC-625, which differs mainly in the hardware connector implementation.

WHERE IS THE BUS USED?—ATEs

Let us consider a small illustration in the use of the bus to introduce the ATE concept, and the bus application. Although one could argue that the example to be presented can easily be achieved manually, consider the full implications of the idea given in the example, the advantages gained, and remember, its only an example.

Consider the manufacturer of small d.c. motors, each motor having to be tested before leaving the factory. The parameters to be measured are winding resistance, run up time, and run current. The instrumentation required is a counter-timer (C/T) a digital multimeter (DMM), a tachometer and a d.c. power supply. The manual method of testing needs no explanation, except to say that a stop-watch would probably be used instead of the C/T. Let us assume that the equipment is connected as shown in Fig. 1, where the switching matrix (consider it as a "black box" for the meantime) connects the Unit Under Test (UUT) to the instrumentation as shown in Figs. 2a and 2b depending on the test being conducted.

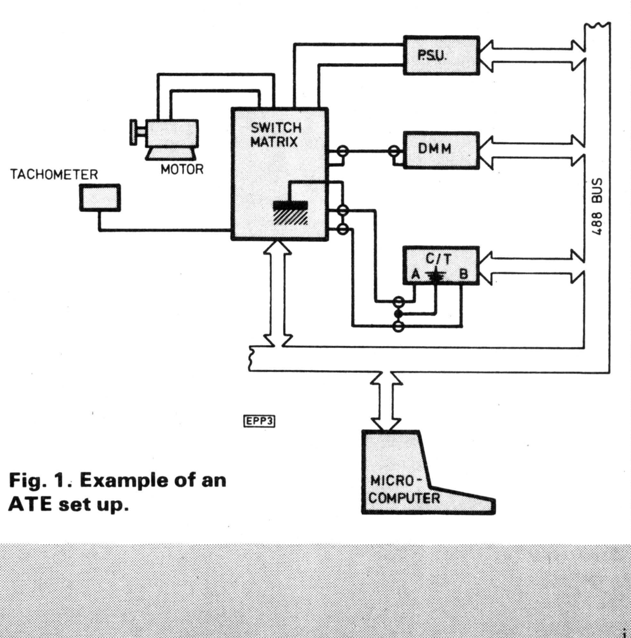
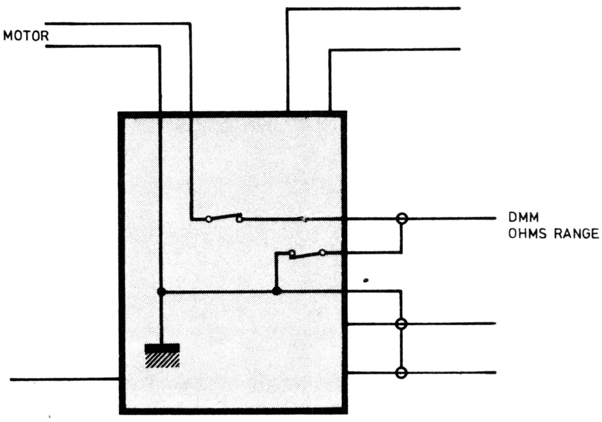
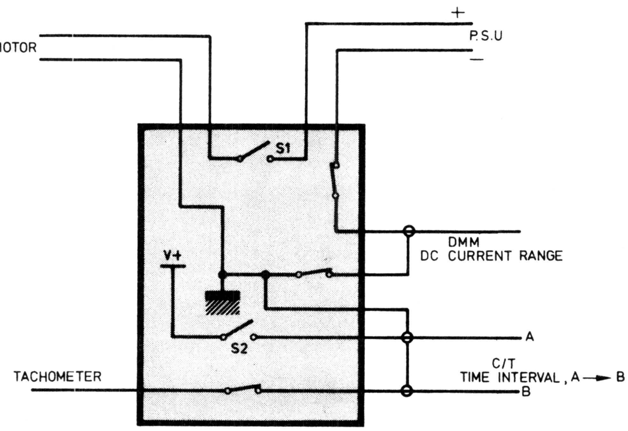


Fig. 1. Example of an ATE set up.



EPP4 **Fig. 2a. Coil resistance measurement**



EPP5 **Fig. 2b. Switching matrix ready to start timing**

The procedure is as follows. On switch on, the computer asks the operator to enter his name, the date, and UUT serial number. The computer prompts the operator to connect the UUT to the jig and, when ready, to hit the RETURN key. Via the bus, the computer will put the DMM into Ohms mode, select the range and configure the switching matrix in Fig. 2a. When the DMM has measured the coil resistance, it will transmit the value back to the computer. The computer then changes the DMM mode to A d.c., programs the power supply for the required drive voltage (this could be read and checked by the DMM as an intermediate step) and configures the switching matrix as in Fig. 2b. The C/T is set up in its time interval mode, which simply measures the time taken betweent two positive pulses appearing at its A channel and B channel respectively. When this has been done, the switches S1 and S2 (Fig. 2b) are closed simultaneously, applying power to the motor, and starting the timing process.

The computer sits waiting for the C/T to finish its measurement and send it back to the computer. The pulse that stops the time measurement is derived from the tachometer, which has been specially designed (the only non-bus instrument) to produce a pulse when the required running speed has been reached. Since the motor is now at speed (the computer has received the run-up time) the computer uses an interface command to tell the DMM to take a current measurement, and return it. When this has been received, the computer opens all the switches in the switch matrix, and a few seconds later a printer churns out a result sheet, like the one shown in Fig. 3 (Produced by an Apple).

SYNCHRO MOTORS

ACCEPTANCE TEST CERTIFICATE

TEST DATE : 81/08/04
OPERATOR : JOHN
SERIAL NO. : M100-70
MOTOR TYPE : 12V DC/M100

TEST		RESULT	LIMITS	UNITS
TEST 1. COIL RESISTANCE		97.8	96 TO 104	OHMS
TEST 2. MOTOR RUN UP TIME	F	0.56	< 0.5	SECS
TEST 3. MOTOR RUN CURRENT		103	< 115	MA

PASSED BY :

SIGNATURE :

DATE :

014 231/81 ISSUE 1

Fig. 3. Results sheet

What was achieved? The test was completely error proof. No misread readings, inaccurate timings, or when applicable, calculation errors. And most important, the actual time-to-test was very significantly reduced. Remember too that the computer sets up the instrument ranges automatically and that self check routines can be incorporated to provide reliable test equipment.

Consider the variety of devices available (a sample will be given below) and one can begin to realise the power automatic testing has, and the cost saving it can produce. The author has recently completed an ATE system that simultaneously tests four highly sophisticated electromechanical devices, using no less than twelve different instruments, all controlled by an Apple! A two hour manual test was reduced to a twenty minute for one, forty five minutes for four, completely automatic, reliable, consistent, test.

SOME DEFINITIONS

The host computer in the example above is for obvious reasons called the CONTROLLER. The switch matrix only receives instructions and is called a LISTENER. The DMM and C/T on the other hand listened to the controller (when their ranges were being set up) and talked back by sending the measurements taken. They are referred to as LISTENER/TALKERS. Most instruments can be switched to be a talker only, so that the instrument is controlled from the front panel, but readings are sent to a controller or another listener (such as a printer).

Fig. 1 indicates that all the instruments are connected to the same bus, so some means of differentiating between instruments

HP5335A universal timer/counter

is required. This is achieved by allocating each instrument a specific ADDRESS between decimal 0 and 30 by selecting that address on a set of switches provided at the rear of each instrument. The controller thus addresses each instrument before sending data to, or receiving data from that particular instrument or device.

BUS DEVICES

The types of bus devices can be broadly divided into different groups. A discussion and explanation of the main groups follows, and examples of each type of device can be found in Table 1, with an indication of which vendors supply what equipment. Note that the list of devices and names of vendors is **by no means complete** and is only meant to be an illustration. Note also that HP, who developed the bus and thus have had most experience with it, have the largest variety of devices available. A glance through the HP instrumentation catalogue is most informative and enlightening.

Controllers

These have already been defined above, and almost always are one form or another of mini- or microcomputer. The HP9825 has for a long while been the industry standard, but today the HP9826 replaces it. Fluke market a sophisticated controller, the model 1720A. And in the less expensive range, although not necessarily less powerful, the Apple or the Pet. Nearly all other mini- or microcomputer manufacturers offer GPIB capability either as a standard, or as an add-on option.

Measurement Devices

A device exists, made by one or other manufacturer, for just about any conceivable measurement requirement. The complexity (and price!) of each variety of instrument in the group ranges from, for example, the simple voltmeter which just sends readings to the controller, to the sophisticated DMM, which can do statistical analysis of the readings taken, or test for readings between pre-programmable limits, or store the highest, or lowest reading taken in any interval of time. The same level of sophistication is also available for many of the other types of devices in this group shown in Table 1.

Stimuli Devices

As the name implies, this group of devices include those which provide analogue or digital stimuli to the UUT, or provide power to the UUT. Again sophistication is built into some of these instruments, so that previous setting up parameters can be stored and instantly recalled, without having to re-program the instrument.

Output Devices

The group includes printers, X-Y plotters, VDUs and the like.

Storage Devices

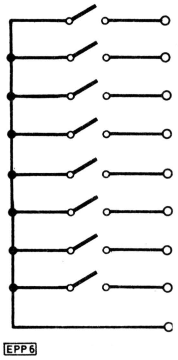
Floppy—and hard disk drives are available.

Switching Matrices

In essence, these devices allow the automatic routing of stimuli to and measurement signals from, the UUT via plug-in modules which consist of sets of relays connected either as in

Table 1. Bus devices and manufacturers—a sample of what is available

	H-P	FLUKE	WAVETEK	RACAL DANA	SYSTRON DONNER	GOULD ADVANCE	KEPCO	ROCKLAND	DIGIPLAN	PHILIPS	TEKTRONIX
MEASUREMENT DEVICES											
Digital Multimeters	3438A 3455A	8860 8520		µ5000	7344A					PM2526 PM2528	
Counter-Timers	MANY	1953A		9514	6042A					MANY	
RF Frequency Meters	MANY									MANY	
Spectrum Analysers	MANY							512-S			492P
Oscilliscopes	TWO									PM3310	MANY
Logic Analysers	MANY					K100-D					
STIMULI DEVICES											
RF Generators	8660A	6070A	MANY								
Synthesizers	3325A		178		1702			MANY		PM5190	
Pulse Generators	5359A		MANY		154-4						
Digital Pulse Gens.	8170A										
DC Power Supplies	59501A 6002A				DPSD-50		MANY			PE1367	
OUTPUT DEVICES											
Printers	MANY										
X-Y Plotters	7225A									PM8151	4662
STORAGE DEVICES											
Floppies	9895										
Digitizers	9874A										
SWITCHING MATRICES											
Switching	3497A			1200	3570A					PM4012	
DACUs											
OTHER DEVICES											
Filters								MANY			
Stepper-motor drives	37201A								1185-105		
HP1B Extenders	59403A										



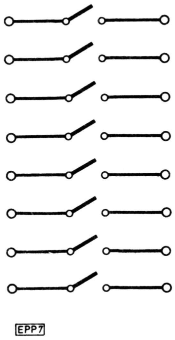


Fig. 4 (far left). Eight relays connected as a multiplex module. Note only one relay may be closed at one time

Fig. 5. Eight relays connected as a relay module. Any number may be closed at any time

Fig. 4 or Fig. 5. They allow measurement and stimuli highways to be formed, an example given in Fig. 6. The number of switches or relays is expandable by simply adding more modules, and different types of modules are available viz. reed relay switching, power relay switching, FET switching and coaxial relay switching amongst others.

Many manufacturers of ATE systems offer modular switching systems and supporting modules such as D/A convertors, A/D converters, peak detectors and the like. HP market various multiprogrammers for measurement and control applications (here called DACUs—for Data Acquisition and Control Units). These have a large variety of plug-in modules to suit. For those with a small business ATE application such as the example above in mind, this type of unit provides the easiest and relatively cheapest way to begin.

Table 2. IEEE-488 standard subsets

Subset Mnemonic	Function
SH1	Source Handshake
AH1	Acceptor Handshake
T5	Talker
TEO	Extended Talker
L4	Listener
LEO	Extended Listener
SR1	Service Request
RL1	Remote/Local
PPO	Parallel Poll
DC1	Device Clear
DT1	Device Trigger
CO	Controller

Other Devices

Analogue and digital programmable filters are available, as well as stepper-motor drives. The list is endless, it keeps growing daily.

MORE DEFINITIONS

It is necessary to say here that the standard divides the major functions of the bus into twelve SUBSETS. An instrument that is a TALKER and a LISTENER implements at least two of these subsets. The controller function is another, for example. Table 2 gives all the possible major subsets, although only a few will be discussed here. Now since an instrument need only implement at least two subsets to be able to communicate in one way or another on the bus, it need only understand the interface messages (or instructions, which they really are) that are com-

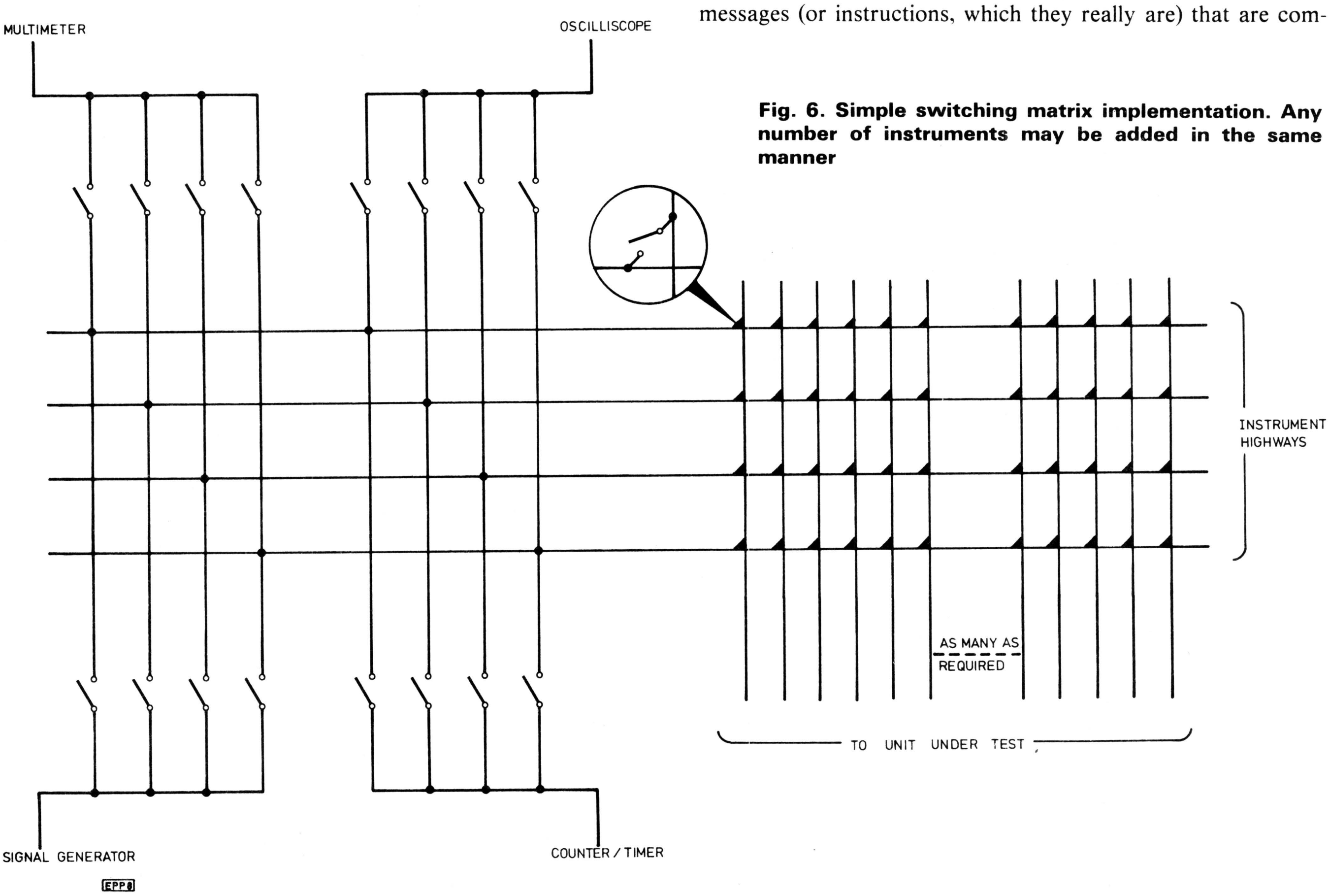


Fig. 6. Simple switching matrix implementation. Any number of instruments may be added in the same manner

mon to those subsets it implements. These interface messages then are instructions that are defined in the standard and must be understood by all instruments, meant to implement the subsets using these instructions. A few of these instructions are discussed in the example below.

Device-dependant messages, on the other hand, are messages that are transmitted by the bus. They usually take the form of either data (measurements) which are normally in a form that all instruments can decode or instructions for the control of the instrument itself (hence "device-dependant") that is normally peculiar only to the instrument being addressed.

It was previously mentioned that the instruments may be set up for any address between 0 and 30 decimal. Referring to Table 3 one can see that corresponding to each decimal address are two ASCII characters depending on whether bit D6 or bit D7 is a "1". These two characters determine whether the instrument is to talk, or listen, when addressed. For example, an instrument set to address 01 would know it was being addressed to talk when it detected an "A" on the bus (MTA—My Talk Address in 488 jargon) and would respond as a listener when it detected a "l" (MLA—My Listen Address).

Now for an example: Assume the controller has address 21 (normal for the HP 9825) and that it is going to set up a Fiuke DMM to measure d.c. volts and return the measurement. Refer to Figs. 7 and 8. Fig. 8 shows the pinout of the 488 controller which will be discussed later, but will be found useful to refer to in the example. The instrument is set to address 04. The following sequence of events occurs.

1 REN line (remote ENable) goes low. All instruments on the bus go into the remote state.
2 IFC (InterFace Clear) pulses low. Stops activity on the bus.
3 ATN line (ATtentioN) goes low. Informs all instruments that the following data is an interface message.
4 NRFD (Not Ready For Data) line is high. This line is one of the three handshake lines and because it is high (remember, the bus works with inverse logic being true) all instruments are ready to accept data. Note that since all the handshake lines have open collector outputs, the line will stay low until the slowest instrument is ready. Thus for all the handshaking, the slowest instrument on the bus determines the speed of the bus.
5 The ASCII character ? for UNL (UNListen) is put on the data lines. This bus instruction deselects any instruments that may previously have been set up as listeners. The character stays on the bus for the whole of the following handshake cycle.
6 DAV line (DAta Valid) goes low. Controller says data is valid.
7 NRFD line goes low. Instruments say do not change data while we are reading it.
8 NDAC line (Not Data ACcepted) goes high when all instruments have accepted the data.

Fig. 8. Bus connector pin-out

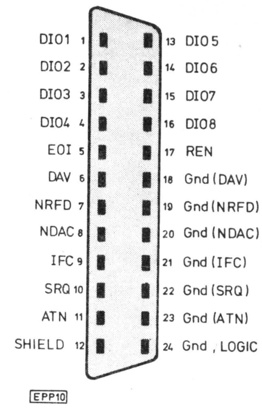


Fig. 7. Bus handshake timing diagram

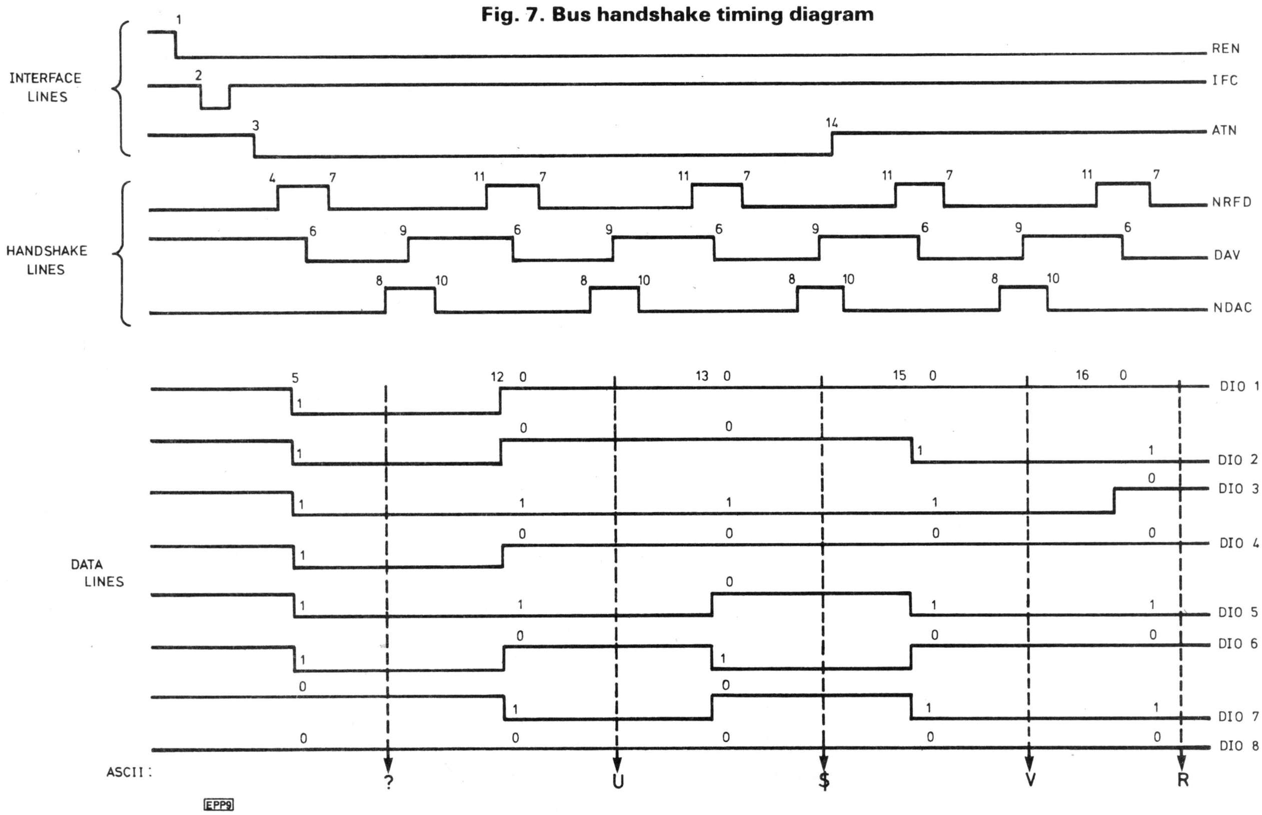


Table 3. Decimal and equivalent ASCII TALK and LISTEN addresses.

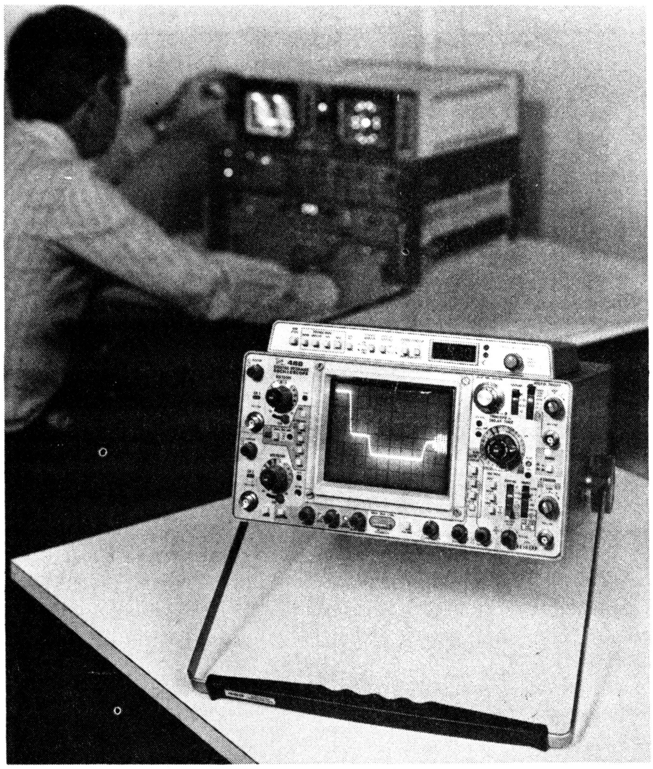
ASCII characters TALK	ASCII characters LISTEN	D_7 TALK	D_6 LISTEN	D_5 16	D_4 8	D_3 4	D_2 2	D_1 1	DECIMAL ADDRESS
	SP	0	1	0	0	0	0	0	00
@		1	0	0	0	0	0	0	
	!	0	1	0	0	0	0	1	01
A		1	0	0	0	0	0	1	
	"	0	1	0	0	0	1	0	02
B		1	0	0	0	0	1	0	
	#	0	1	0	0	0	1	1	03
C		1	0	0	0	0	1	1	
	$	0	1	0	0	1	0	0	04
D		1	0	0	0	1	0	0	
	%	0	1	0	0	1	0	1	05
E		1	0	0	0	1	0	1	
	&	0	1	0	0	1	1	0	06
F		1	0	0	0	1	1	0	
	(APOSTROPHE)	0	1	0	0	1	1	1	07
G		1	0	0	0	1	1	1	
	(	0	1	0	1	0	0	0	08
H		1	0	0	1	0	0	0	
	)	0	1	0	1	0	0	1	09
I		1	0	0	1	0	0	1	
	*	0	1	0	1	0	1	0	10
J		1	0	0	1	0	1	0	
	+	0	1	0	1	0	1	1	11
K		1	0	0	1	0	1	1	
	,	0	1	0	1	1	0	0	12
L		1	0	0	1	1	0	0	
	—	0	1	0	1	1	0	1	13
M		1	0	0	1	1	0	0	
	.	0	1	0	1	1	1	0	14
N		1	0	0	1	1	1	0	
	/	0	1	0	1	1	1	1	15
O		1	0	0	1	1	1	1	
	Ø	0	1	1	0	0	0	0	16
P		1	0	1	0	0	0	0	
	1	0	1	1	0	0	0	1	17
Q		1	0	1	0	0	0	1	
	2	0	1	1	0	0	1	0	18
R		1	0	1	0	0	1	0	
	3	0	1	1	0	0	1	1	19
S		1	0	1	0	0	1	1	
	4	0	1	1	0	1	0	0	20
T		1	0	1	0	1	0	0	
	5	0	1	1	0	1	0	1	21
U		1	0	1	0	1	0	1	
	6	0	1	1	0	1	1	0	22
V		1	0	1	0	1	1	0	
	7	0	1	1	0	1	1	1	23
W		1	0	1	0	1	1	1	
	8	0	1	1	1	0	0	0	24
X		1	0	1	1	0	0	0	
	9	0	1	1	1	0	0	1	25
Y		1	0	1	1	0	0	1	
	:	0	1	1	1	0	1	0	26
Z		1	0	1	1	0	1	0	
	;	0	1	1	1	0	1	1	27
[		1	0	1	1	0	1	1	
	<	0	1	1	1	1	0	0	28
\		1	0	1	1	1	0	0	
	=	0	1	1	1	1	0	1	29
]		1	0	1	1	1	0	1	
	>	0	1	1	1	1	1	0	30
∧		1	0	1	1	1	1	0	

9 DAV goes high. Data no longer valid.
10 NDAC low. Instruments remove data accepted indication.
11 NRFD goes high. Instruments ready for next data byte.
12 Controller puts character U on the bus indicating that it is going to be the talker. Steps 6 to 11 are repeated, i.e. the handshake is completed.
13 The controller puts $ on the bus. This is the Fluke's LISTEN address. Steps 6 to 11 are repeated, however, only the DMM is doing the handshaking, as only it recognises its listen address. Until stated to the contrary, steps 6 to 11 occur after each byte of data is transmitted, and are controlled by the DMM and the controller only.
14 ATN goes high. Interface message finished, device dependant message follows.
15 V on the bus. The DMM understands this to mean Volts d.c. This and the following few characters are totally device-dependant messages and are understood by the particular instrument only.
16 R range
17 ? Auto range
18 M Programs off
19 0
20 T Internal trigger
21 0
22 ? Terminator that forces the DMM to act on this string of data and take a reading, i.e. on V d.c. and auto range.
23 CR Carriage return. Indicates to the instrument end of data message.
24 LF Line Feed
25 ATN low—following message is an interface one.
26 ? on data bus—Unlisten again (all instruments respond).
27 D on data bus—Controller tells Fluke it must talk. Only the Fluke recognises this, so again, only it will respond.
28 5 on the bus—Controllers' own listener address.
29 ATN high. end of interface message. The DMM can now send its measurement.

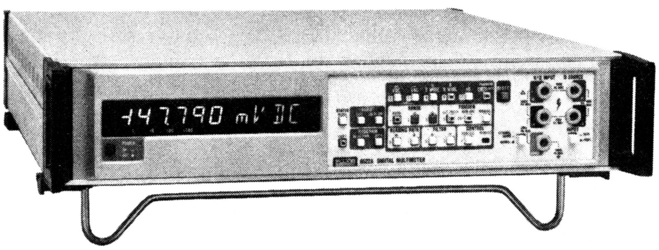
30 +
31 0
32 0
33 0
34 0
35 .
36 0
37 3
38 E
39 +
40 0
41 2

It may seem a bit long-winded to go through all that to transfer data, but it takes just a fraction of a second to occur, and the handshake ensures correct data transmission. Another explanation of the handshake cycle is shown in the form of a flow chart in Fig. 9. In the above example, when the controller is talking, it is referred to as the SOURCE and it controls the DAV line, while the DMM, which is listening, is called an ACCEPTOR, and controls the NRFD and NDAC lines. The names and lines each device controls are of course reversed when their respective listen and talk roles are reversed.

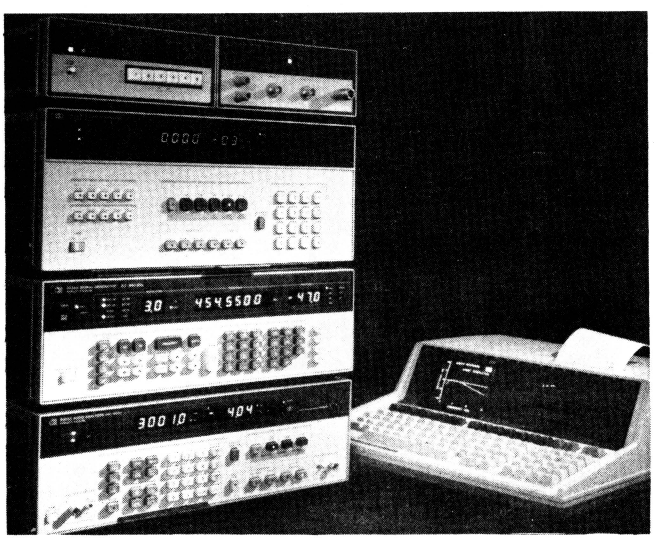
The only other line so far not discussed is the SRQ (Service ReQuest) line. This line is used by instruments to indicate to the controller that they require service. The instruments can be programmed to ask for service when some special conditions occurs, such as a hardware or software or programming error,



Tektronix 468 digital storage oscilloscope



Fluke 8522A computing/systems DMM



Hewlett Packard 8903A transceiver test set under the control of an HP85F

when a reading has been completed, or when some other, or combination of other, instrument-defined conditions occur. The controller then does either a Serial or Parallel Poll to discover which instrument sent the SRQ and acts on the SRQ as programmed. The actual Serial or Parallel Poll implementation is outside the scope of this article.

MORE INTERFACE DEFINED INSTRUCTIONS

A few more interface defined instructions, which are used most often, follow. They can be broadly grouped as shown and are all sent with the ATN line low.

Unaddress Commands

These do what the name implies.

UNL—UNListen	Clears the bus of all listeners (ASCII ?)
UNT—UNTalk	Clears the bus of all talkers (ASCII ∧)

Universal Commands

All instruments respond to these commands, whether they had previously been addressed or not.

LLO—Local LOckout	Disables front panel controls (ASCII DC1)
DCL—Device CLear	Returns all devices to a cleared state (ASCII DC4)

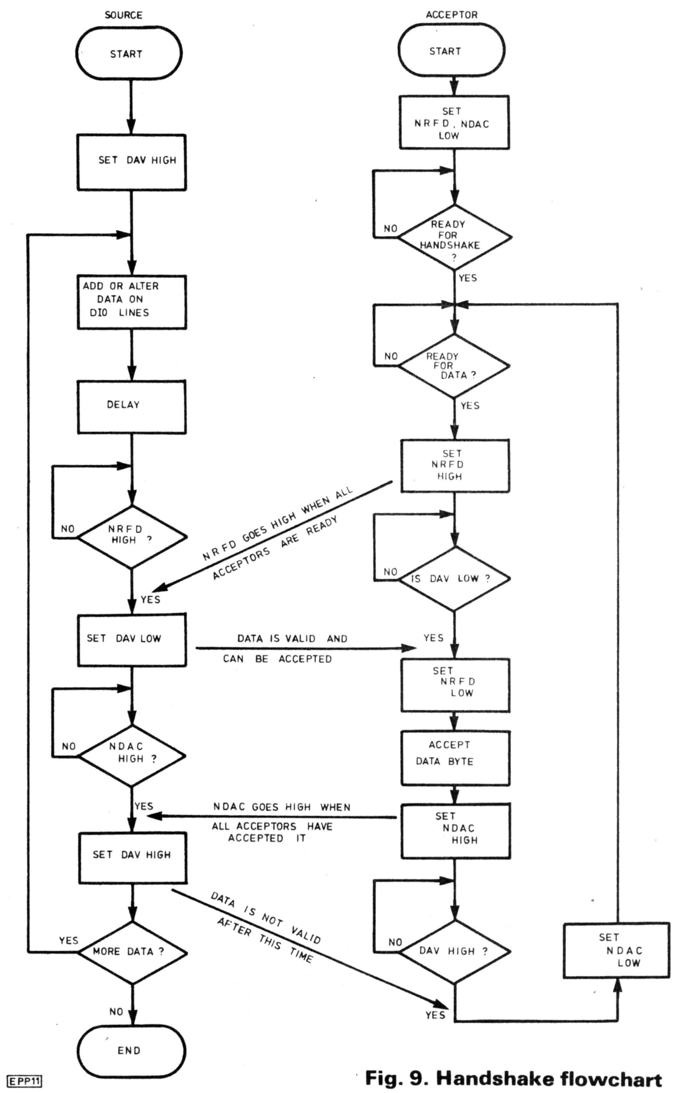
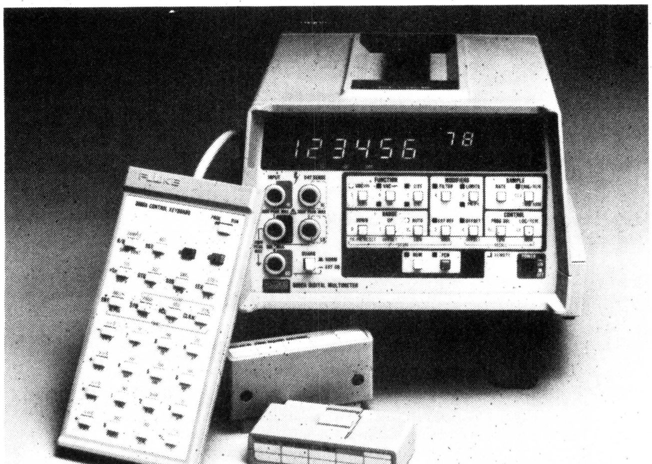


Fig. 9. Handshake flowchart



Fluke 8860A DMM

Other commands in this category are commands that allow Serial or Parallel Polling as mentioned above. Refer to Ref. 1 for more details.

Addressed Commands

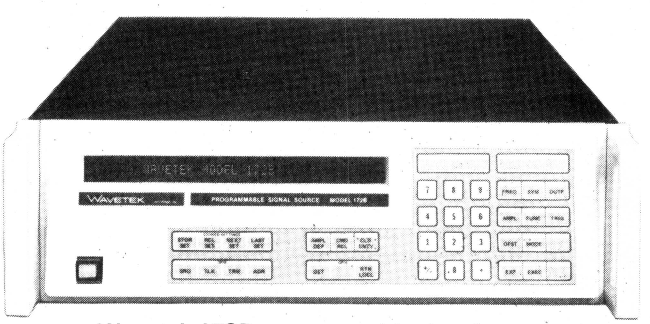
Commands which affect addressed instruments only.

GTL—Go To Local	Enable the devices front panel controls (ASCII SOH).
SDC—Selective Device Clear	Clears only the selected (addressed) device on the bus (ASCII EOT).
GET—Group Execute Trigger	Start-all preset-up instruments simultaneously (i.e. to start taking a measurement — ensures simultaneous measurements with different devices).
TCT—Take Control	Pass control from the present controller to another. This facility is seldom found on controllers, mainly due to the complexity of providing the facility and because the facility is seldom required.

There are many others, but these examples suffice to show the bus capabilities.

HARDWARE

The physical connector, as already mentioned, is shown in Fig. 8. The bus standard allows for a maximum of 15 instruments at one time (including the controller) and a total cable length of 20 metres. Buffer units are available to expand this, but are rarely required. Standard cables are available to do the interconnecting and must usually be ordered separately from the device manufacturers.



Wavetek 172B programmable signal source

Table 4. IC's—types and manufacturers

Manufacturer	Part Number	Function	Supply (V)	Clock (MHz)	Transfer Rate (bytes/sec)
Fairchild	96LS488	Talker/ Listener	5	10	1M
Intel	8291	Talker/ Listener/	5	8	448k
	8292	Controller	5	6	
Motorola	MC68488	Talker/ Listener	5	1-1.5	125k
Philips/ Signetics	HEF4738V	Talker/ Listener	4.5-12.5	2	200k
Texas Instruments	TMS9914	Talker/ Listener/ Controller	5	5	250k

BUS INTEGRATED CIRCUITS

The major chip manufacturers, Motorola, Intel, Fairchild, Philips and Texas Instruments all produce VLSI integrated circuits which can be used as building blocks for building a bus interface. The chips are designed to work with their respective microprocessor families, however they can be used with other micros as well. For amateur use, the Motorola MC68488 chip is probably the best to use, as it interfaces well with the 6502 microprocessor, which is the micro used in most home computers. Table 4 shows some of the versions available.

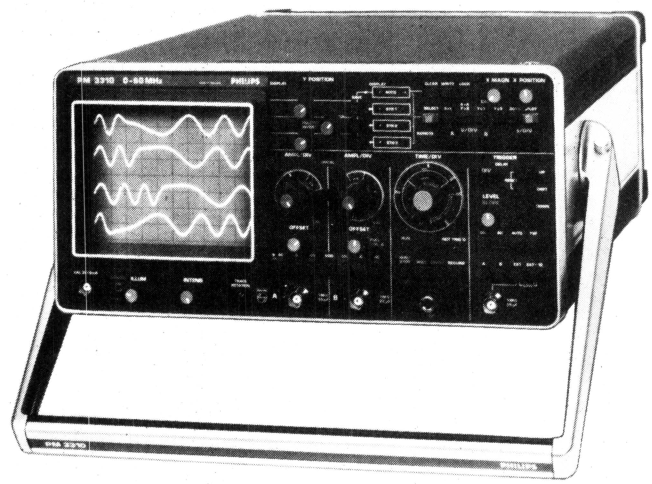
Although the task of designing one's own interface seems nearly impossible to the hobbiest at first glance, this is not really so. The integrated circuits are not expensive, application data is freely available and the chips themselves remove most of the complicated work. It is in this area that the hobbiest can really get going without too much expense.

CONCLUSION

It is hoped that some light has been thrown on ATEs in general and the IEEE-488 bus in particular. Perhaps (hopefully!) some minds have been set thinking and home computers (and others) may now be used in a new direction, as well as for the usual financial uses and of course, games!

(Ref. 1—IEEE STANDARD DIGITAL INTERFACE FOR PROGRAMMABLE INSTRUMENTATION—published by the IEEE inc. New York.)

If you do use your computer in this way or are interested in so doing, perhaps you could let us know (Ed.)



Philips PM 3310 digital storage oscilloscope

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"Old Time, that greatest and longest established spinner of all" (Dickens), "that old bald cheater Time" (Jonson), "Old Time, the clock-setter, that bald sexton Time" (Shakespeare), "that old common arbitrator, Time" (ibid.), "the nurse and healer of all good" (ibid.), "the soul of the world" (Pythagoras), "the Life of the soul" (Longfellow), "the author of authors" (Bacon), "the greatest innovator" (ibid.), "the devourer of things" (Ovid), "the illimitable silent, never-resting thing called Time" (Carlyle), "a short parenthesis in a long period" (John Donne), "a sandpile we run our fingers in" (Sandburg), "the tooth of time" (Shakespeare), "Time's revolving wheels" (Petrarch).

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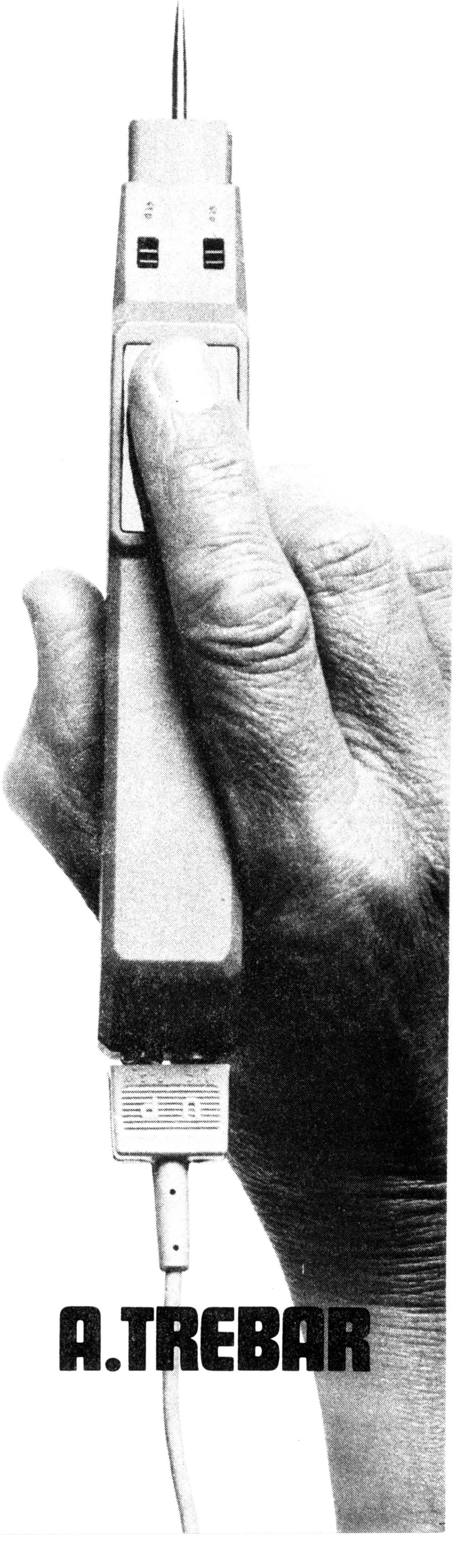
"Time rolls his ceaseless course" (Scott).

Signature Analyser

IMPROVEMENTS in technology have brought about a lot of changes in digital circuitry design. Random logic designs have been replaced by software based designs such as microprocessors and algorithmic state machines. Hardware has been replaced by processor's firmware. Elements like ROMs and PROMs contain programs that represent software algorithms for control circuits. Methods for testing digital modules that are software oriented are quite different from those used to test random logic. Instruments like an oscilloscope and DVM are no longer sufficient. The problem can be solved partly by using a logic state analyser. The algorithm can be traced and when the erroneous state occurs, the faulty element can be sought.

A simple logic probe is a very economic and useful device but unfortunately it can display only a few states of digital circuitry. It cannot distinguish different data streams in different nodes of digital circuits. This article describes a digital logic probe that can display not only 'low', 'high' and 'pulse train', but also a stream of digital data at different nodes of circuit inside a predefined time window. The probe is in fact a miniature hand held Signature Analyser.

The circuit has been kept as simple as possible, so that it can be implemented with standard elements and yet can be placed in an enclosure no bigger than that of an ordinary logic probe. Testing digital boards with this handy tool is quite easy only if the boards are designed so that the circuit under test generates signals which can be used for generating a time window in which the periodic stream of digital data at different nodes can be observed.



A. TREBAR

DEFINING IT

A Signature Analyser is an instrument for testing and de-bugging digital circuitry. The most essential part of the device is a CRC encoder that serves as data compressor. CRC stands for 'cyclic redundancy check' which is an error checking technique commonly used in serial data transmission or data recording systems (discs, tapes, etc.). Digital data stream compression is obtained by polynomial division of data by the generator polynom. The remainder of this is the CRC value or signature of a particular data stream.

Division is implemented in a serial shift register, where feedback loops determine the generator polynom. The remainder is always in relation to all data bits in the digital stream that entered the feedback register. Fig. 1 illustrates the principle of operation.

By comparing the signature in a node of a circuit to an empirically determined correct signature, we can verify circuit operation. The element where all signatures on the inputs are correct and signatures on the output pins are incorrect is the faulty one and should be replaced.

DESIGN OF THE PROBE

The probe is intended to test digital circuits with TTL signal levels. It is designed to be as small as possible so as to be no bigger than an ordinary logic probe. It is also built with standard SSI and MSI integrated circuits. Since a relatively large number of elements is placed in a small enclosure, problems related to power dissipation might occur. The use of CMOS elements has solved this but CMOS elements are relatively slow devices when used with 5V power supply and thus the maximum frequency of input signals is 50kHz. Signatures can be observed on a 4-digit seven segment multiplexed display. The selected characters are presented in Table 1.

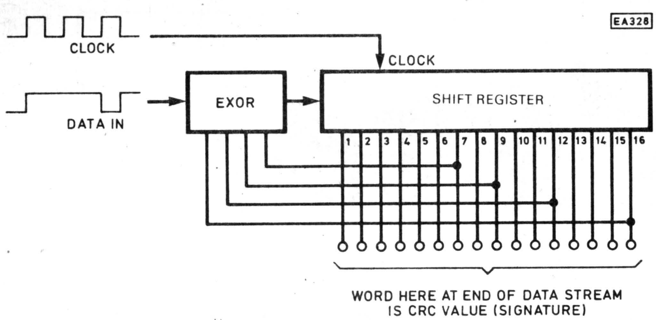


Fig. 1. The CRC encoder

SIGNAL INPUTS

The following signals are inputted to the probe:

Clock Is the clock of the **unit under test** (UUT). Because of speed limitation the clock of the UUT should be slowed down to 50kHz.

Start Time window in which the measuring takes place is started by a start pulse. This signal is also generated by UUT. The probe is designed so that the beginning of the time window can be selected on the falling or rising edge of the start pulse.

Stop Stop pulse terminates the time window. The termination of the time window can be selected on the rising or falling edge of the stop pulse.

All signals mentioned above are entering the probe through the microphone jack on the rear side of the probe.

Data Is a digital data stream of the unit under test that enters the probe through the probe tip.

Power Probe is connected to a power supply of UUT by alligator clips.

Table 1: HEX-to-alphanumeric decoder

2^3	2^2	2^1	2^0		a	b	c	d	e	f	g
0	0	0	0	0	1	1	1	1	1	1	0
0	0	0	1	1	0	1	1	0	0	0	0
0	0	1	0	2	1	1	0	1	1	0	1
0	0	1	1	3	1	1	1	1	0	0	1
0	1	0	0	4	0	0	1	0	0	1	1
0	1	0	1	5	1	0	1	1	0	1	1
0	1	1	0	6	1	0	1	1	1	1	1
0	1	1	1	7	1	1	1	0	0	0	0
1	0	0	0	8	1	1	1	1	1	1	1
1	0	0	1	9	1	1	1	1	0	1	1
1	0	1	0	A	1	1	1	0	1	1	1
1	0	1	1	C	1	0	0	1	1	1	0
1	1	0	0	F	1	0	0	0	1	1	1
1	1	0	1	H	0	1	1	0	1	1	1
1	1	1	0	P	1	1	0	0	1	1	1
1	1	1	1	U	0	1	1	1	1	1	0

CIRCUIT

Fig. 2 is the circuit diagram of the logic probe. The whole can be divided into three basic parts: a circuit for generating the time window, data compressing circuit and a circuit for latching signatures and multiplexing the display.

The circuit for data compression is implemented by IC1, IC2 and IC5. IC1 and IC2 are connected to form a 16-bit shift register with serial input and parallel outputs. Bits 7, 9, 12 and 16 are EXORed together with the data input stream in IC5. The result of this summation is made to enter a serial input shift register.

The data stream enters the linear feedback shift register during a preselected 'time window', which is determined by start and stop signals.

This is generated with circuits IC8 and IC9. IC9 is a quad NAND gate, and a half of it is connected to form an RS flip-flop. A start pulse triggers the flip-flop by a negative going pulse at IC9/13. This initiates the time window. When a negative pulse is applied to IC9/8 the window period terminates. The other half of IC9 and four Schmitt triggers from IC8 are used to generate short negative going pulses for triggering the RS flip-flop. By setting the switch S1 we can select whether the triggering pulse will appear at the leading or trailing edge of the input pulse. Fig. 3 illustrates how trigger pulses are generated. Note that the trigger pulse width is determined by propagation delay of the Schmitt trigger. During the window time the serial data stream is entering the linear feedback shift register. After the appearance of the stop pulse information contained at the parallel output pins of the feedback register represents the signature of the stream.

The signature is loaded to IC3 and IC4 which are parallel input—serial output shift registers and are used for storing the signature and for multiplexing the display. The signature is jammed into the register via the parallel input lines asynchronously of the clock at the positive pulse (1µs) on IC8/8 and displayed on a 4-digit seven segment l.e.d. display (HP-5082-7405).

DISPLAY

The circuit for displaying the signature is implemented by IC3, IC4, IC6, IC7, IC8 and IC10. Shift registers IC3 and IC4 (CD 4021B) are parallel input—serial output devices, with three parallel outputs: Q6, Q7 and Q8. Two are used for multiplexing the display.

The serial outputs of IC3 and IC4 are connected to the serial inputs of the same units so that information in the shift registers is cycling with the frequency of a clock provided by UUT. Parallel outputs Q7 and Q8 from IC3 and IC4 are connected to the address pins of IC7 (6331) which is 32 × 8 PROM, used for binary to seven segment code conversion as is shown in Table 1. All segments of the l.e.d. display are directly driven from IC7 with the exception of segment f which is driven by IC10 a-b. The display is multiplexed by applying negative pulses to the common cathode outputs of IC11 at the time when correct data is waiting at the address input of IC7.

IC6 is BCD by 8 counter divider. When the signature is loaded to IC3 and IC4 the L/S pulse at IC8/8 clears IC6 and so synchronises it with the contents of IC3 and IC4. Since the information contained in IC3 and IC4 is cycling, the valid output at Q7 and Q8 will only be at each second clock pulse. That is why only each second output of IC6 is used for driving the common cathodes of the l.e.d. display. However CMOS circuits like the 4022A cannot sink enough current to drive a l.e.d. display directly, so IC10 is used as a cathode driver.

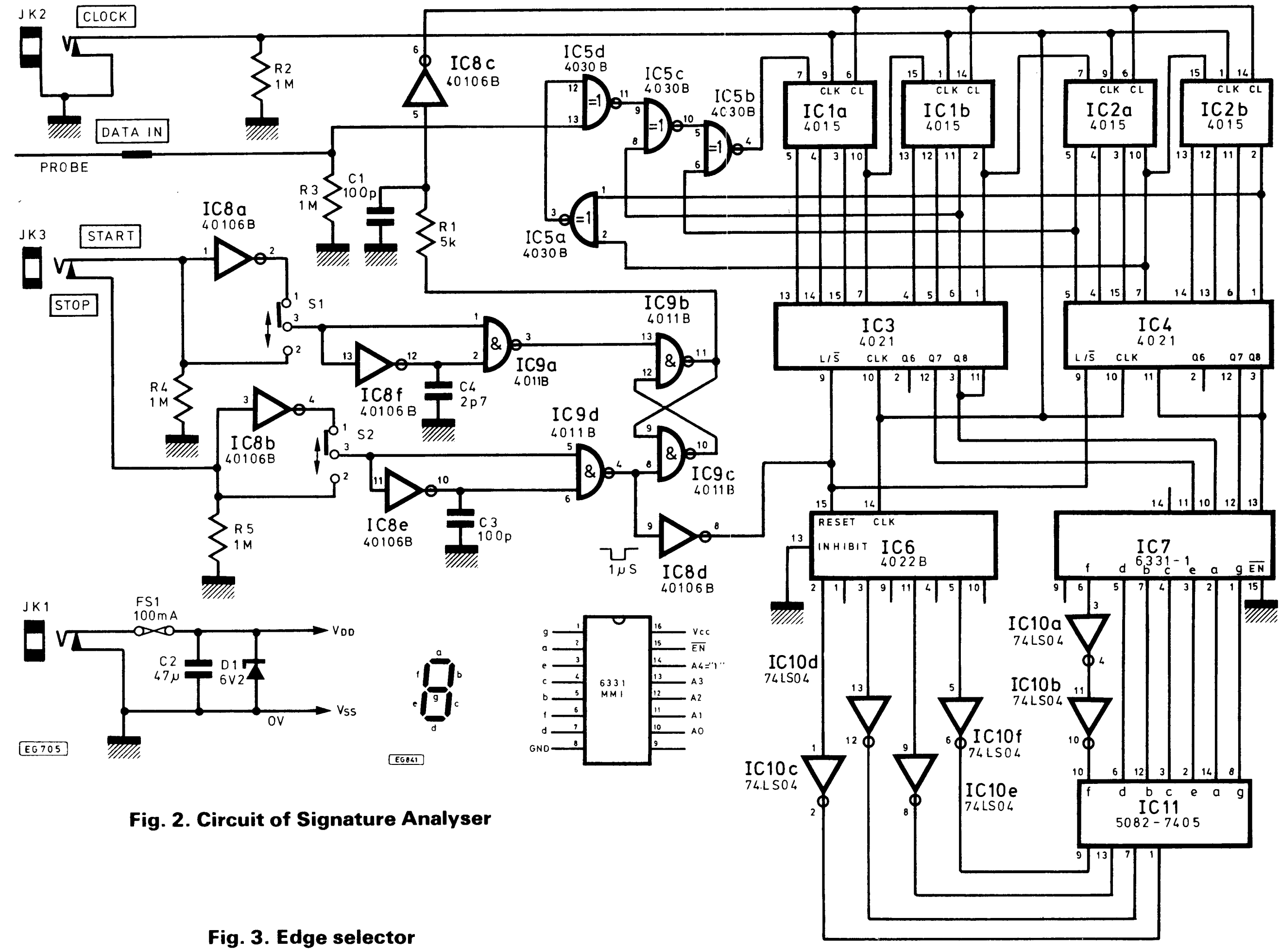
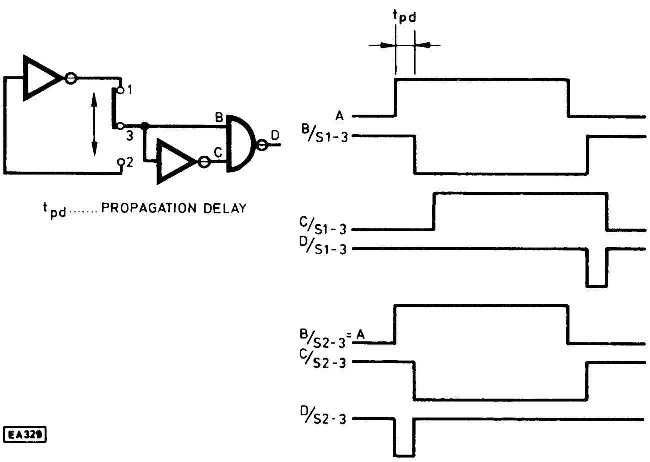


Fig. 2. Circuit of Signature Analyser

Fig. 3. Edge selector



CONSTRUCTION

The circuit is implemented on two single sided printed circuit boards which are mounted vertically in the enclosure. The boards are positioned so that the interconnection between chips is as simple as possible. Fig. 4 shows the component placement and foil pattern. Fig. 5 illustrates how the display is soldered to the p.c. board. Pins from 1 to 7 are stretched and are then soldered. The other pins are soldered to the jumpers so that when the board is mounted in the enclosure the display can be easily observed through the display bezel/filter on top of the probe. Control signals (Start, Stop and Clock) enter the probe through phono jacks on the rear end of the probe. The cable to the probe should be short enough to avoid ringing problems. For a given frequency this won't occur if the cable is no longer than 1m.

The data stream enters the probe through the tip. Two switches on top of the probe are provided for selecting the time window. These are miniature SPDT type.

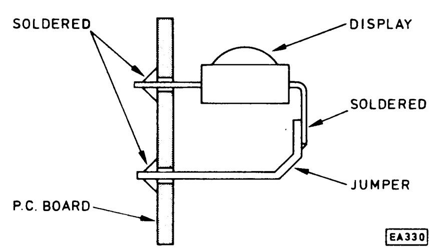
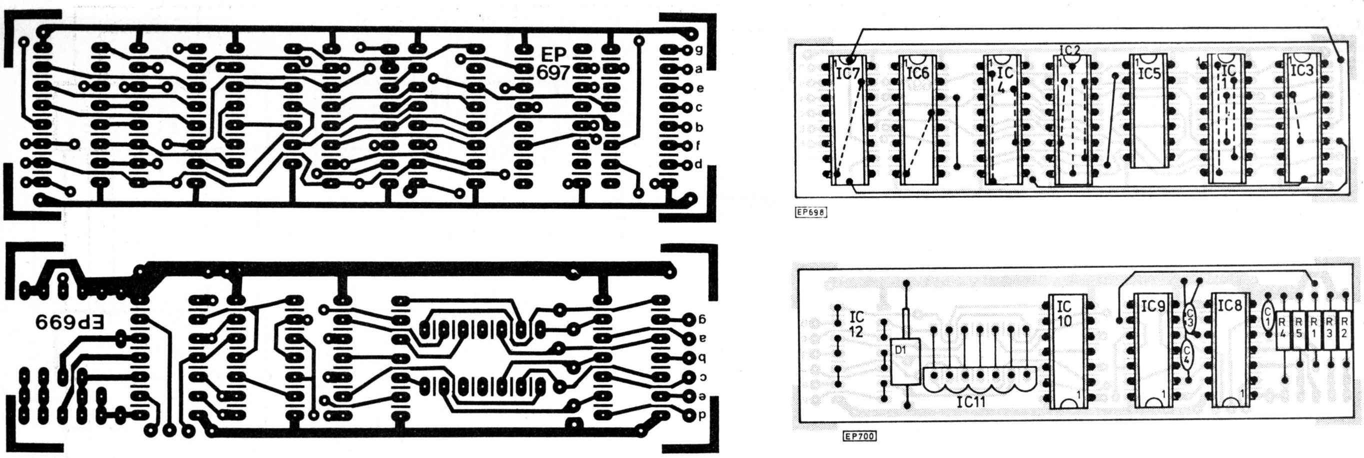
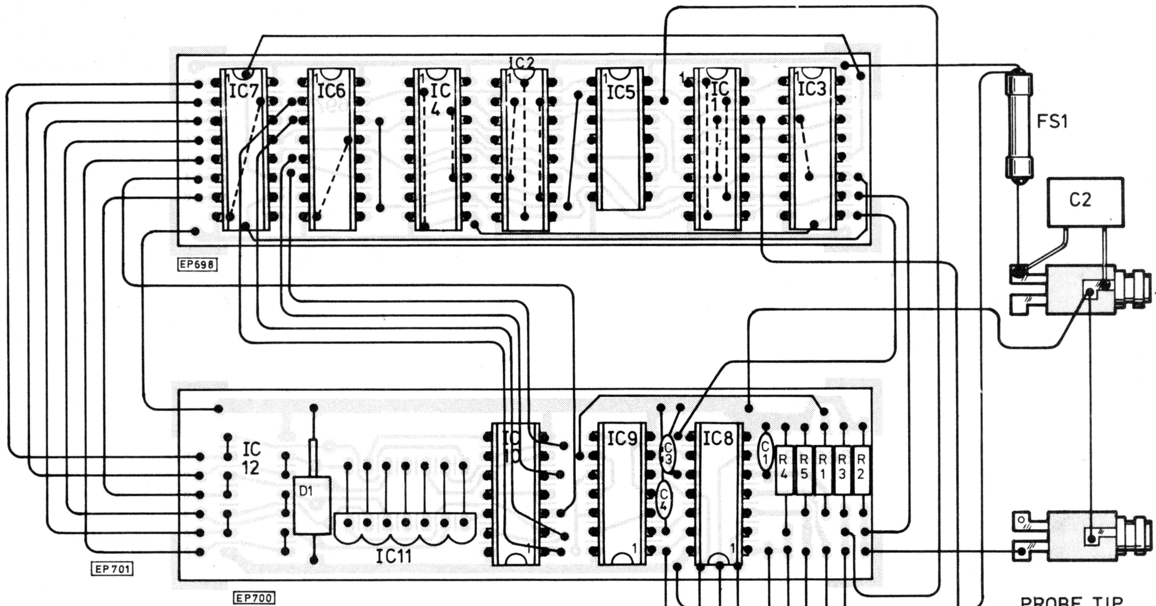


Fig. 5. Showing how display is soldered to p.c. boards

USING THE PROBE

How useful the probe could be is evident from a relatively simple problem. Let's assume that we need to test the content correctness of a 2K × ROM circuit. We can see that the task is not an easy one if we have to read the contents of every address location and then compare it to the value in





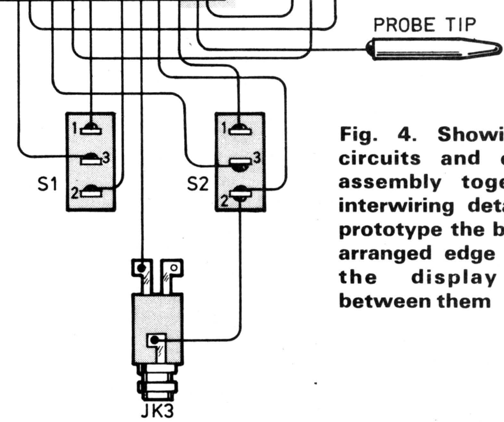


Fig. 4. Showing printed circuits and component assembly together with interwiring details. In the prototype the boards were arranged edge on so that the display appears between them

COMPONENTS . . .

Resistors

R1	5k	
R2–R5	1M	
R6	5k	
$\frac{1}{4}$ watt 5% carbon		

Capacitors

C1/C3	100p
C2	47µ 25V electrolytic
C4	2·7p

Semiconductors

D1-BZX 85/C6V2	Zener diode, 6·2V, 1·3W
IC1-IC2 CD4015	Dual 4-stage SIPO shift register
IC3-IC4 CD4021B	8-stage PISO shift register (asynchronous parallel input)
IC5-CD4030B	Quad exclusive OR
IC6-CD 4022B	Divide by 8 counter/divider
IC7-6331-1	PROM 32 × 8, three state (MMI)
IC8-CD40106B	Hex Schmitt trigger
IC9-CD4011B	Quad 2-input NAND
IC10-74LS04	Hex inverter
IC11-5082-7405	5-digit, common cathode numeric indicator (Hewlett-Packard)
IC12-7404	Hex inverter (optional)

IC7 and IC11 can be obtained from **Ace Mailtronix Ltd., 3A Commercial St., Batley, West Yorks, WF17 5HJ**

Miscellaneous

FS1	100mA/fast
JK1–JK3	miniature 2·5mm chassis connector (RS 478-526)
S1–S2	miniature SPDT switch

case, tip, pins, cable, clips, PC-boards.

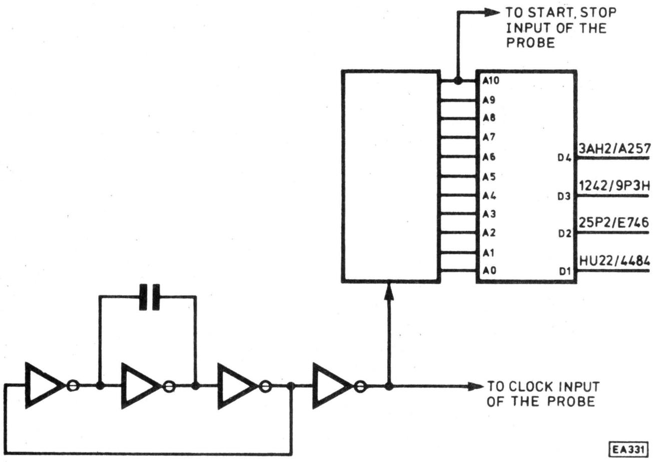


Fig. 6. Contents of the display when the probe tip is successively applied to the output pins

the truth table. Testing such ROMs with the probe is fast and easy. It should be connected to a free running binary counter which scans all the addresses. Start and stop signals are taken from the most significant bit of the address counter and the switches are set so that the time window opens at the leading edge of the MSB address bit and terminates at the trailing edge. The oscillator input should be connected to a free running oscillator or binary counter. The probe tip should be successively applied to the ROMs outputs. The only thing we have to do now is to compare the signatures from the probe with the signatures empirically determined from the known good ROM. Now one half of ROM has been tested. To test the other half we must change the switches and repeat the operation. The example described above is illustrated in Fig. 6.

The best results can be obtained if circuit of unit under test is designed with the concept of signature analysis in mind. This means that it must be designed so that feedback bus loops can be opened. The problem is that unless the feedback loops are not broken, the failure in one member of the loop will propagate bad signatures all the way around the loop. ★

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FOR SALE MY kit system seven electronics kit. As new £25. David Donaldson, 13 Rossole Road, Enniskillen, Co. Fermanagh, N. Ireland.

WANTED tremelo unit published PE May 1976. Must be working and sound like "Leslie" rotary system. John McGrory, 88 High Street, Old Aberdeen. Tel: 0224 491016.

CASIO VL TONE for sale. Almost new, £25. Usual price £35·95. Adam Talbot, 153 Court Lane, West Dulwich, London SE21. Tel: 01-693 4238.

AUDIO Generator Belco AG761, Sine/Square wave, 19Hz–220kHz, Phone outputs, £35. Tel: 051-734 0987.

WANTED National Semiconductors LM373 IF AMP with AGC any quantity. Tel: Terry, G6AAB, Farnborough 47436.

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UK101 cased 8K, extra RAM chips bare expansion board, new monitor, 00/600 baud, offers. P. Bellis, 132 Knighton Road, Itchen, Southampton, Hants. Tel: Southampton 0703 433608.

WANTED, back issues of electronics magazines, PE, before 1979, EE issues for September 1976, October 1977. S. G. Mitchell, 39 Munnings Close, Blackdam, Basingstoke, Hants.

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Semiconductor UPDATE...

FEATURING LM363 TL783 74HC SERIES

R. W. Coles

MONOLITHIC INSTRUMENT AMP

A major problem encountered when connecting transducers to their attendant amplifiers is the dreaded "common-mode-noise." Common-mode simply means that the noise voltage is induced in both connecting wires equally in sign and magnitude, and this is the normal situation where the connecting wires act rather like receiving aerials. If the amplifier has a so called "single-ended" input (i.e. single and earth) the induced noise voltage is amplified along with the signal, which is bad news of course. To overcome this problem you can use an OP-AMP along with four resistors in a differential input configuration so that advantage can be taken of the Common Mode Rejection Ratio (CMRR) of the amplifier. In this circuit the equal voltages induced in the two leads are cancelled out by the equal gains and opposite signs produced by the plus and minus OP AMP input terminals. The desired signal from the transducers, being a difference voltage, is not cancelled and is amplified as required by this circuit.

So with today's OP AMPs featuring CMRRs of 100,000 (usually expressed as 100dBs) or so, the problem is solved—or is it? Well, no actually. That 100 dB figure is not easily attainable in a practical differential OP-AMP circuit because balancing the inputs correctly would call for *exact* values for the four resistors and that is not possible using ordinary 5% types. Even if very expensive 0·1% resistors are used, you will still not achieve anywhere near 100dBs, and there is another problem inherent in such a simple circuit, the low input impedance which is set by the resistor values, and which is unlikely to get much above 10K ohms for 741 type OP AMPs.

If the lowly 741 and four resistors was not good enough, in the past you had to turn to a highly expensive "Instrumentation Amplifier," originally available in module form and more recently produced in the form of thick or thin film hybrids which while certainly being smaller, are still expensive. The Instrumentation Amplifier circuit traditionally uses three OP-AMPs with two in the high impedance non-inverting configuration dedicated to each input and the third acting as the differential stage to give a ground referenced output. This configuration has a very high input impedance and excellent CMRR, but is difficult to make with, say, three 741s because resistor tolerances are still a problem. That's why you may not have heard of Instrumentation Amps, until now you have had to do without their special advantages because of their cost! But not for long thanks to National Semiconductor and their LM363 which is a true Instrumentation Amplifier on a Monolithic chip costing a fraction of earlier designs. The LM363 comes in a tiny 8 pin T05 can and needs no external resistors for correct operation because you buy the gain you need built in—10, 100, or 500 versions are currently available but soon there will be a 16 pin DIP version with gains selected by strapping pins. The 363 offers a 120dB CMRR and a super high input impedance requiring only 2 nano amps of input bias current.

DMOS REGULATOR

In the field of voltage regulation, there seemed to be hardly any frontiers left for regulators to conquer, but Texas Instruments have decided to tackle one of the few remaining with a new device which is designed to work at a much higher input voltage than has ever been possible before. Their new TL783 device is a positive output adjustable three terminal device which is able to operate with an input-output voltage differential of up to 125 volts! Until now, most adjustable regulators could manage only 40 volts, but by a clever combination of their bipolar and DMOS FET technologies Texas have shattered the high voltage barrier with a single low cost monolithic chip which will also deliver up to 700 milliamps provided that the voltage-current product does not exceed 20 watts. High voltage circuits are notorious for their short term transient conditions which could cause the Safe Operating Area (SOA) of a regulator to be exceeded leading to burn-out due to local hot spots, or even so-called secondary breakdown in the power devices used. The designers of the TL783 have not ignored these problems and have built in two separate protection systems to make the device virtually indestructible. A thermal protection system will shut the TL783 down if the chip temperature climbs too high, and a current limiter ensures that the 20W rating is not exceeded even under transient conditions.

Voltage regulation is good, with input voltage changes causing output changes of less than 0·02% per volt and load current changes causing only a 0·5% change in output voltage. Due to the DMOS series pass device however, the minimum input-output voltage differential is higher than usual, 10 volts at 400mA.

HIGH SPEED CMOS

When RCA first introduced its 4000 series CMOS logic in 1969 it became an instant success because for the first time it was practical to power a logic system from batteries. Despite the attractions of the 4000 series however, I could never quite understand why RCA had decided to use different pin-outs and logic functions to those in the then standard 74 series TTL family. Later, when National did the right thing and brought 74C series CMOS with TTL pinouts, I felt sure that RCA's 4000 series would soon be superseded, but I was wrong!

The 4000 series was soon established as the premier CMOS family and was second sourced by many other manufacturers, including National, while the family which I had backed languished in the wings waiting for its big moment to come. With the huge and growing family of 4000 series MSI parts it often seemed that the more humble 74C range would never make it, but now thanks (paradoxically) to microprocessors 74C is back with a vengeance. The touble is, 4000 series and 74C devices have never been very fast, and that has not gone very well in microprocessor circuits where LSTTL has of necessity been the standard logic family—until now. With increasing pressure for faster and lower power microprocessor circuits the time is now ripe for a new fast CMOS logic family to provide the nuts and bolts of microprocessor systems, and since these systems are currectly hooked on LSTTL the pinouts of that family are a must for a new CMOS series.

In a bold move, National and Motorola are both introducing a new family of fast CMOS parts with TTL pinouts—The 74HC series. The part numbers in this series will sound familiar to all TTL users, 74HC00 quad nand gate, 74HC74 dual D type flip-flop, 74HC245 octal bus transceiver, and so on, but ever mindful of the momentum in the 4000 series following, National and Motorola have hedged their bets by also including devices such as the 74HC4002 quad nor gate which has a 4000 series pinout!

This new initiative is bound to succeed, because these devices will be able to replace not only LSTTL but also 74C and 4000 series CMOS by having the twin virtues of high speed *and* very low power consumption. Take the 74HC00 for example, it will switch in 10 nanoseconds, the same as 74LS00, and very much better than the nearest equivalent 4000 series part the 4011, which needs about 100 nanoseconds at five volts. As for power, well the 74HC00 takes about 12 microamps from a 5 volt supply at 10kHz as against 8 microamps for the 4011 and 1·2 *milliamps* for the 74LS00. These specs mean that you can plug 74C devices directly into 74LS sockets to save power, or into 4000 sockets to speed things up.

Function Generator

ANDY FLIND

IN the electronics workshop an almost indispensable item of equipment for any type of work is a source of suitable test signals. For audio and low frequency work, the function generator is becoming increasingly common as the source of these signals since the choice of three output waveforms, sine, square or triangle, can be used to check the performance of almost any type of circuit encountered.

A major contribution to the popularity of this type of generator was the introduction a few years ago of the 8038 waveform generator chip. This device is now virtually an industry standard, and is used in many commercially produced generators costing eighty pounds or more. However, it's possible to construct an excellent instrument for about a third of this cost. Several designs have already appeared in the hobby press, but most of these so far have been based on the fairly simple circuit provided with application notes for this chip. This circuit works but it does leave a certain amount to be desired in terms of performance; for the instrument presented here the best possible performance from the 8038 was sought at the expense of a little extra circuit complexity.

CIRCUIT

From the designers' point of view the 8038 is a versatile device, but it might be said that it's a little unfinished. For a start, the three outputs are at different voltage levels and are sourced from medium to high impedance. Most designs employ a single amplifier to buffer them, the gain being varied by the function selector switch, but due to the high impedance levels this leads to some deterioration of performance at higher frequencies, especially in the case of the

SPECIFICATION

Frequency Ranges:
1–10Hz
10–100Hz
100Hz–1kHz
1–10kHz
10–100kHz
Ranges cover approx. 0·5 × lowest value to 1·1 × highest value of nominal range

Output Waveforms:
Sine, square and triangle.
Separate sync output of 16V p-p square wave available to drive scope timebase, frequency meters, etc.

Main Output Ranges:
0–0·1mV
0–1mV
0–10mV
0–100mV
0–1V
Output source impedance is constant 50 ohms at all settings

Distortion:
Sine wave, better than 1% THD
Triangle linearity, better than 1%
Square wave rise time, approximately 100ns

Provides sine, square and triangular output waveforms

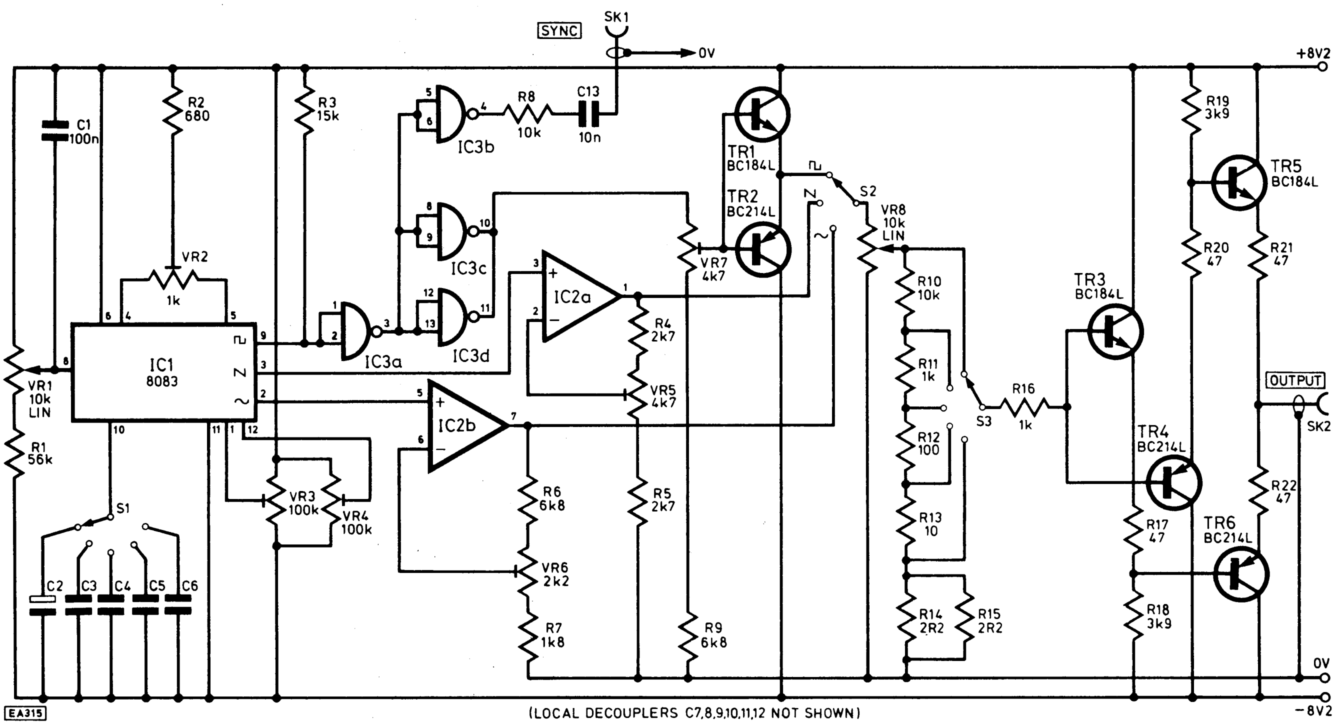


Fig. 1. Circuit of generator

square wave. To avoid this problem this design uses separate buffer amplifiers to bring the three outputs to the same voltage level and convert them to low impedance. Fig. 1 shows the complete circuit of the instrument. The triangle and sine are processed by amplifiers IC2a and b, their levels being adjusted by VR5 and VR6. The squarewave is taken from the open collector of a transistor in the chip, hence the need for the pull-up resistor R3, and is handled rather differently. A CMOS quad NAND gate chip, IC3, is employed here. The first gate "a" buffers the output and improves its switching time. Gate "b" provides a completely isolated sync output, useful for driving external monitoring equipment, such as synchronising a scope timebase via an external trigger input, or coupling to a frequency meter. Gates "c" and "d" are connected in parallel to drive level adjuster VR7, and the output is then buffered to low impedance by TR1 and TR2.

The initial levels of all the waveforms in this design are set to 10V peak-peak. The component values given in some other circuits have been selected to give approximately equal r.m.s. amplitude outputs; however this results in wide differences in the peak-peak values of the three waveforms. As an instrument of this type is generally used in conjunction with an oscilloscope calibration for equal peak-peak values seems more suitable.

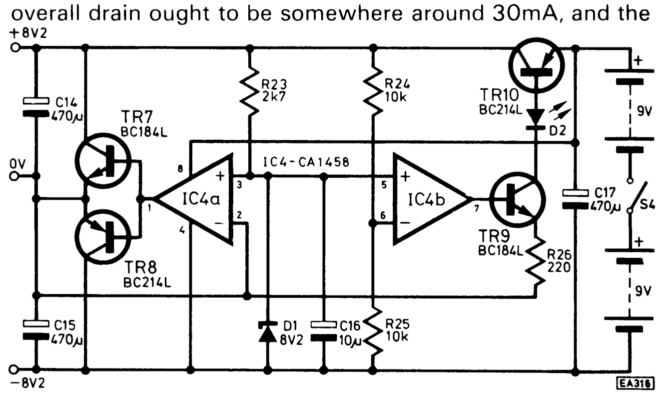
After buffering the required waveform is selected by switch S2 and passes via the "Fine" level control VR3 to the decade attenuator network and "Coarse" level selector switch S3.

The output stage consists of a discrete complementary emitter follower circuit, offering low noise, good small-signal handling ability, excellent high frequency response and a constant output impedance of 50 ohms.

The power supply section of the circuit appears in Fig. 2. A battery supply was chosen for this project as it provides portability, complete safety, and avoids the problems of hum and noise, etc., which might occur at low output levels if a mains supply were to be employed.

CONSTRUCTION

With the exception of the timing capacitors, attenuator resistors and the "low battery" l.e.d., all the components used in this project are mounted on a single printed circuit board. The component layout appears in Fig. 4, and the copper foil pattern in Fig. 5. Construction of this board should prove straightforward provided reasonable care is taken to ensure correct orientation of diodes, transistors, i.c.s and electrolytics. IC1 is a bipolar device and thus needs no special handling care, but the usual precautions should be observed for the CMOS IC3. Sockets can be used for the i.c.s if preferred. Suitable lengths of wire should be soldered to the completed board ready for connections to the controls etc. The use of ribbon cable here will produce a tidier finished assembly. It's a good idea to test the board before continuing. One of the timing capacitors can be connected to the leads intended for S1, and the appropriate leads can be shorted together to connect each buffered signal in turn directly to R16—there's no need to have S2, VR8, S3 and the attenuator in circuit for this test. VR1 and the l.e.d. should also be temporarily connected, and all the presets should be set to mid-travel. If an 18V supply is now applied to the battery connections the circuit should operate. The overall drain ought to be somewhere around 30mA, and the



supply voltages from the regulator should be checked with a meter across C14 and C15. The output can be checked on a scope, or with headphones, providing the value of timing capacitor selected gives signals within the audio range.

The front panel layout can be seen from the photograph. Wiring to the panel should be kept short and neat; some of the connections between the controls can be carried out before the panel is installed. The switches S1, S2 and S3 are 2-pole 6-way types with adjustable stops to allow them to be set to the number of ways required. Unwanted tags are cut off to prevent confusion during wiring. The resistors used in the attenuator are 1% thick film types; the cost of the extra precision amounts to only a few pence.

The nominal values of the timing capacitors are as follows: C2–10µ, C3–1µ, C4–100n, C5–10n, C6–1n. Most of these values are not easily obtained in close tolerance, so if the frequency control calibration is to be reasonably accurate they will have to be selected by trial and error using a frequency meter. With C6 stray capacitances become significant; on the prototype a bunch of small polystyrene capacitors totalling about 820p gave the desired results. C3, 4 and 5 can be polyester or polycarbonate types, different specimens can be tried until adequate results are obtained. 10µ is not readily obtained as a non-electrolytic, so a tantalum bead was decided upon for C2. These are usually higher than their stated value; of a batch of five tried on the prototype all gave too low a frequency. A pair of 4µ7 tantalum beads in parallel instantly produced the correct range however, so this appears to be the best approach. With reasonable care over capacitor selection the output frequency can easily be within ±5% of dial settings over the entire range of the instrument.

The overall internal layout can be seen from the photograph. The p.c.b. is screwed directly to the pillars provided in the Verobox and the two batteries are held firmly in place with a short length of "Dexion" angle; a bracket made from sheet metal could be used instead.

SETTING UP

Adjustment of the presets is obviously easier if a scope is available, although it can be carried out reasonably well with a good quality analogue (not digital) voltmeter. Begin with VR2, which adjusts the mark-space ratio. This must be as close as possible to 50–50, at which point the average d.c. output will obviously be zero. Set VR8 and S3 for minimum (zero) output and check the output voltage with a meter; it may be zero, but if a small offset exists due to mismatches in the output transistors etc., note its value. Then select squarewave output at 500Hz and full amplitude, and carefully adjust VR2 until the same output d.c. value is obtained.

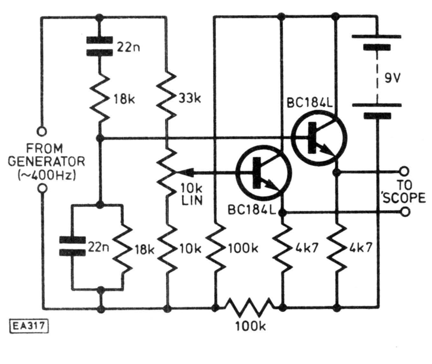


Fig. 3. Filter used when adjusting VR3 and VR4 (sine purity) potentiometers

The sinewave linearity pots VR3 and VR4 should be set next. A scope is an absolute "must" for adjusting these, if access to one cannot be obtained omit these two pots. Connect IC1 pin 12 to the negative supply via an 82k resistor and leave pin 1 open circuit. This will give quite acceptable results but an improvement can be obtained with correctly adjusted presets. Begin by monitoring the sinewave output at about 400Hz and adjusting VR3 and VR4 until the output looks reasonably sine-shaped. Quite good results can be obtained visually, but for the absolute optimum the circuit of Fig. 3 should be temporarily constructed and used to assist the process. This consists of a Wien Bridge filter with a pair

COMPONENTS...

Resistors

R1	56k
R2	680
R3	15k
R4, R5, R23	2k7
R6, R9	6k8
R7	1k8
R8, R24, R25	10k
R16	1k
R26	220
All 5% $\frac{1}{3}$W carbon	
R10	10k
R11	1k
R12	100
R13	10
R14, R15	2·2
R17, R20, R21, R22	47
R18, R19	3k9
All 1% thick film	

Potentiometers

VR1, VR8	10k lin. carbon	
VR2	1k	Sub-min horizontal presets
VR3, VR4	100k	Sub-min horizontal presets
VR5, VR7	4k7	Sub-min horizontal presets
VR6	2k2	Sub-min horizontal presets

Capacitors

C1, C8, C9, C10, C11, C12	100n ceramic disc
C2, C3, C4, C5, C6	see text
C7	47µ 25V electrolytic
C13	10n polyester
C14, C15, C17	470µ 25V electrolytic
C16	10µ 25V electrolytic

Diodes

D1	BZY88C8V2 8·2V 400mW Zener
D2	sub-miniature, red l.e.d.

Transistors

TR1, TR3, TR5, TR7, TR9	BC184L
TR2, TR4, TR6, TR8, TR10	BC214L

Integrated Circuits

IC1	8038 waveform generator
IC2	CA3240E
IC3	4011BE
IC4	1458C

Miscellaneous

S1, S3, single pole, 5-way; S2, single pole, 3-way; S4, single pole, single throw; Case, Vero type 202-21036G, 205 × 140 × 110mm; Output sockets, BNC or coax, surface mounting; battery clips, p.c.b. materials, control knobs, ribbon cable.

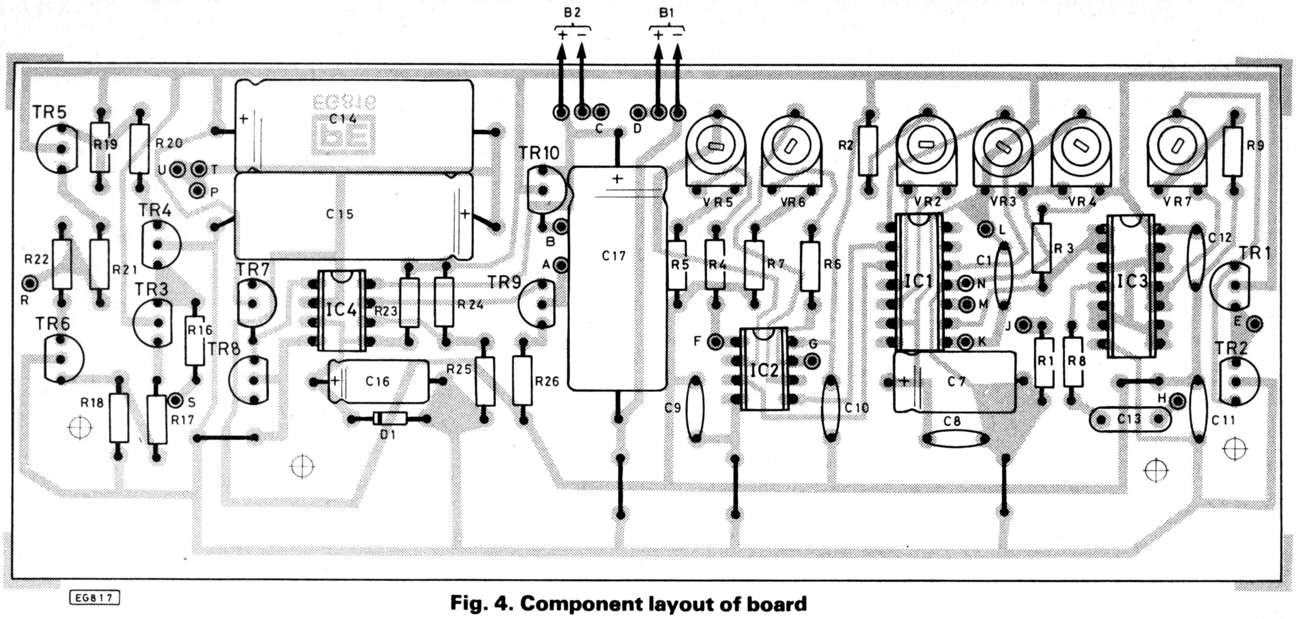


Fig. 4. Component layout of board

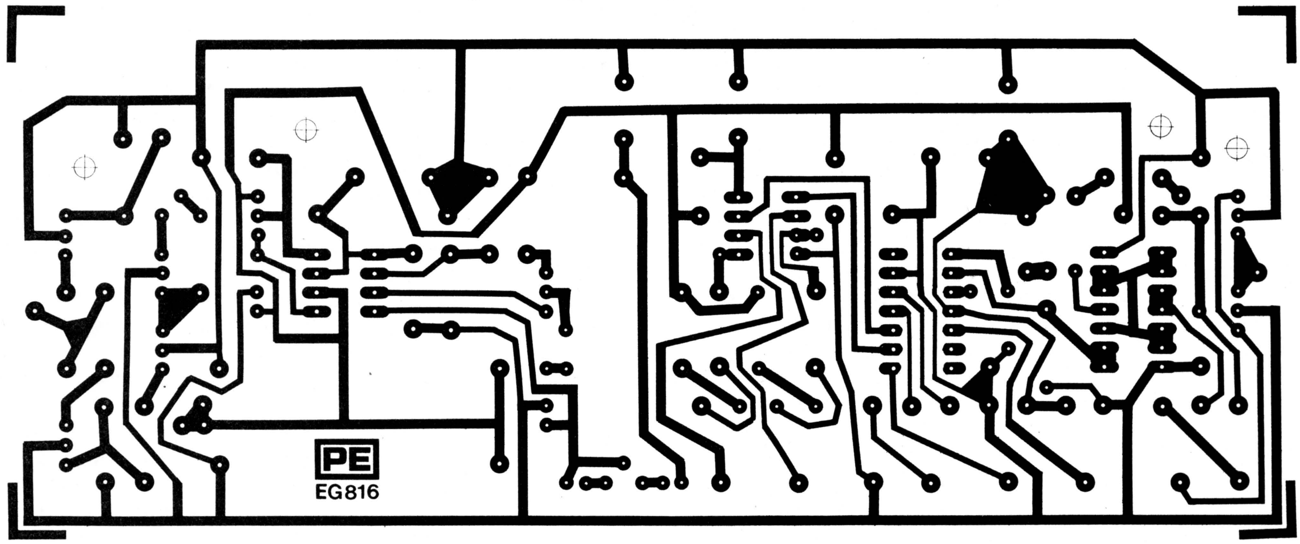


Fig. 5. Printed circuit

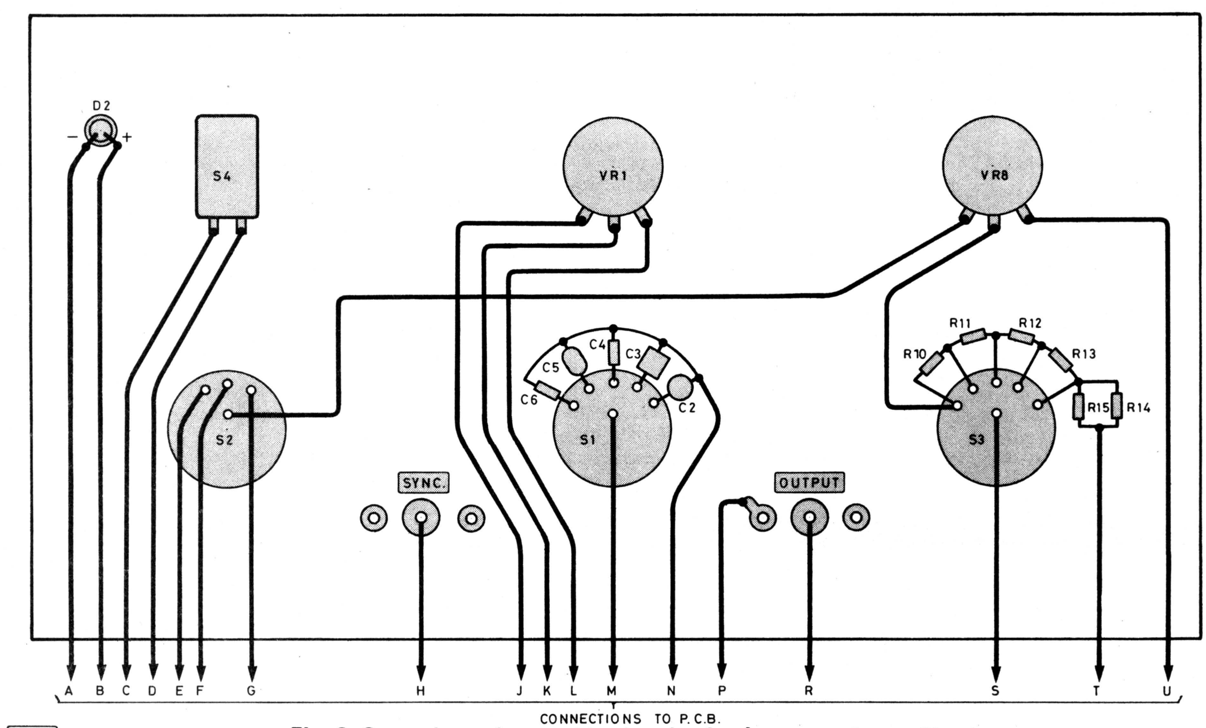
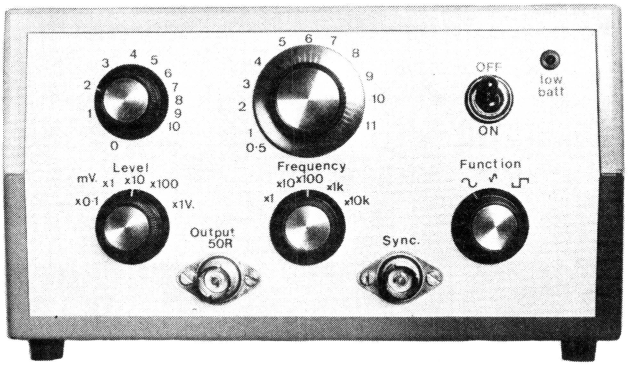
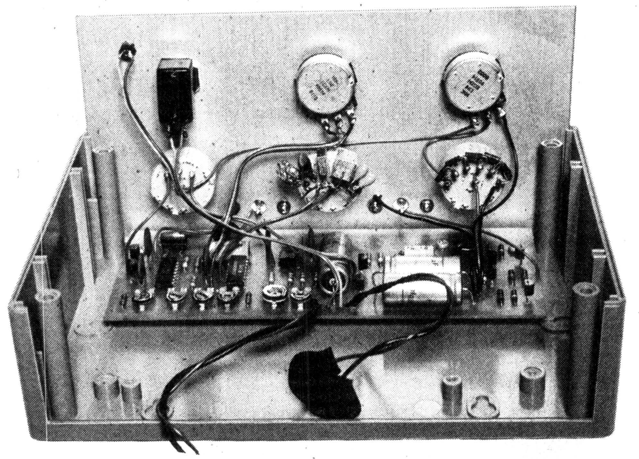


Fig. 6. Control panel assembly showing leads connecting to Fig. 4





of output buffers, and it will completely remove the fundamental sinewave at about 400Hz, leaving only the distortion components. The 10k pot should be used in conjunction with the generator's frequency control to obtain the deepest possible null; the residual signal still visible will then consist almost entirely of harmonics and VR3 and VR4 can be adjusted to reduce this as far as possible.

This leaves VR5, 6 and 7, respectively the triangle, sine and squarewave output level adjusters. If your scope will monitor the output voltage accurately they can be adjusted to give 10V peak-peak maximum output for each waveform. This adjustment can be made with a meter however, if a 470μ capacitor is temporarily connected across one of the timing capacitors. This will slow the output frequency down so much that it can be accurately monitored with the meter; note that 10V peak-peak means 5V peak either side of zero!

Calibration of the "Fine" frequency control VR1 will require a frequency meter, but the calibration of VR8 can be carried out easily with a meter if the frequency is slowed as above and the squarewave output is used. Note that the action of VR8 is not linear owing to its slider being loaded by the attenuator chain, but the calibration of VR1 should be linear across its full range.

USING IT

This instrument has been designed to be as quirk-free as possible. In general its frequency and voltage output should be within 5% of that set on the controls; there are no problems such as change of amplitude with frequency etc., and the waveforms, including the squarewave, remain excellent all the way up to 100kHz. Perhaps the only failing is some breakthrough of the squarewave into the sine and triangle at the lowest output range (0–1mV). If really low levels are required it may be advisable to use a higher level and place an attenuator at the input of the circuit under test. The lowest output purity is quite adequate for most purposes though, hence its retention in the design.

The circuit is d.c. coupled throughout to avoid distortion at very low frequencies. Due to component tolerances, nonlinearities in the chip etc., there may be a small offset voltage on the output (a few millivolts); also the output will not take kindly to large d.c. voltages placed across it from the equipment under test, so remember to use an isolating capacitor where necessary. Both sync and main outputs will withstand short circuits without damage, although prolonged short circuiting of the main output is not recommended.

The generator is intended to work into impedances of 1k or greater but in fact has enough power to produce sound from 8 ohm loudspeakers, at reduced voltage of course due to the 50 ohm output impedance. Note that working into low impedance reactive loads will distort the waveform. ★

BAZAAR

SALE of Practical Electronics from very first issue. Will sell individually or the lot. Tel: 01-529 0612.

LAMBRA Compudialer 749 complete with mains adapter, £30. Also AP25 Linear Amp £15. Mr. P. Thompson, 46 The Stirrup, Stroud, Gloucestershire. Tel: 045-36 5918.

8K PET small key-pad model £300. Tel: Sheffield 386402.

WANTED: obsolete British transistors EW, GET, WKT, V, series, etc. Circuit cards welcome. Write for offer. Mr. A. Wylie, 18 Rue de Lausanne, 1201 Geneva, Switzerland.

SWAP b/new TR7800 and AR240 complete for FT220 FT221R TS7005 P. Turner, 51 Weyland Road, Ipswich IP6 9ET.

AIRMEC signal Gen., 30kHz–30MHz £12, pair PYE PF1's, stalled for RB14, modded for PP3's, £20. Michael Gathergood, G4KFK, 80 Moorfield Road, Denham Green, Uxbridge, Middx. UB9 5NF.

SINCLAIR multimeter (digital) DM1; working fine, but case slightly damaged near switches. Most interesting offer secures. Laurence Cook, 7 Plum Tree Close, Ecclestone Park, Prescot, Merseyside L35 7JT. Tel: 051-426 5138.

ATARI computer game console, controllers, mains adaptor, £75. Chess £25. Invaders £20. Basketball £10. Tel: Rayleigh 747845.

OSCILLOSCOPE CT52 in original carrying case, great condition £40 or W.H.Y? buyer to collect. John Sartorius, 52 Caulfield Drive, Greasby, Wirral, Merseyside L49 1SW.

SALE Sharp portable radio air 108 136 MHz MW 520 1620kHz, £11, including post & packing. Mr. K. Mealor, 38 Bishopgate Street, Liverpool L15 1EW.

500 American radio magazines perfect condition £20. Collectors items, Radiolympia catalogues, American radio catalogues, offers, collect. L. Marks, 14 Avenue Road, Kingston, Surrey KT1 2RB.

SUB-MIN relays 15K & 700R Ex-eqpt, cased with sockets & clips 2P C/O contacts, 75p each + p.&p. D. Woolcock, 33 Bank Place, Ashton, Preston, Lancs. PR2 1DN.

INSTRUCTIONS wanted on loan to copy—Telequipt D43 oscilloscope—147 George Road, Erdington, Birmingham.

NASCOM 1 cased PSU16K board P.I.O. sound zeap and Naspen on tape manual, offers. Tel: Great Yarmouth 0493/55622.

CASED Superboard, expansion board, p.s.u., Cassette recorder, and software £95. Data Dynamics 390 RO printer £85. Mr. R. W. Hearn, 10 Speedwell Close, Pakefield, Lowestoft, Suffolk.

OHIO Superboard 8K 32 × 32 display. 1200/300 Baud cassette 1·5MHz. Smartly cased. Software inc. asteroids assembler £165. Tim Groves, Burnham-on-Sea. Tel: 0278 785845.

BI-PAK 2240 teak amp cabinet chassis sockets facia knobs new $\frac{1}{2}$ list price £10 plus carriage. G. A. Noble, 50 Crofthill Road, Slough, Berks. SL2 1HF.

WANTED: Hewlett Packard model 33 teletype spares. Anything considered. Send any information to: Nicholas Belson, 20a Furzedown Road, Highfield, Southampton.

40K UK101 10K Basic Cegmon interface boards, assembler editor £425 o.n.o. SAE details or phone evenings. Simon Riddle, 51 Marshalwick Lane, St. Albans, Herts. AL1 4UT. Tel: 0727 53946.

CLEF PE Master Rhythm as new 01-578 5448, £70.

SINCLAIR DM2 $3\frac{1}{2}$ Digit bench type multimeter with mains adaptor £25. Phone evenings (Liskeard) 0579 43749.

SUPERBOARD 8K and 8K plus case, p.s.u. and programs £150 o.n.o. Alan Biase, 041-637 8897 (Glasgow).

UK101 Speech synthesiser. Plugs into PE's Decoding Module. Infinite vocabulary, sample software, smart case. Only £55. Mr. P. Coates, 94 Haddington Road, Whitley Bay, Tyne & Wear. Tel: 0632 513887.

FRANK W. HYDE

SIX MOONS FOR SATURN

Further examination of the Voyager data indicates from the imaging processes that there are definitely four more moons to add to the satellites of Saturn and the possibility of two more yet to be confirmed. A member of the research team S. P. Synott found an object 217mi. from Saturn between the orbits of the satellites Tethys and Dione. He found another at a point about 60deg. preceding the satellite Dione. Synott also found a third and fourth companion of Tethys in what he termed a horseshoe orbit but they were at the limit of resolution. Still another possible satellite was observed as a streak in a Voyager photo. The indication in this case was that the object was about 219000mi. from Saturn and between the orbits of Dione and Rhea.

Together with R. Terrille, Synott also found a new satellite at about the same orbital distance from Saturn as its satellite Mimas. This object was identified previously from the data of the Voyager 2 charged particle detectors. It is estimated that this satellite is about 6 miles in diameter. The rest of the other new satellites would seem to have possible diameters which lie between 9 and 12mi.

ARIEL VI SWITCHED OFF

At the end of February 1982 the UK/ARIEL scientific satellite was switched off according to programme and the ground station at the Rutherford and Appleton Laboratory shut down. The history of the achievements of itself and its predecessor Ariel V has been outstanding. Not only is the data extensive but also far greater than the original design programme. The team at the RAL, were almost a small family group, so integrated with each other that they were able to anticipate conditions and act so that the gas for attitude control lasted far beyond the expected period. Many subtle ways of handling the management have been the means of bringing forward data of great value.

The final scientific experiments were carried out between the 8th and 19th of February. The satellite spin rate has now been reduced to such a low level as the result of aerodynamic drag that it is not possible any longer to make stable scientific experiments. Previously there had been two successful 'spin-up' manoeuvres thus prolonging the life of the satellite.

Ariel VI was the last in the series of the Science and Engineering Research Council experiments. Four Universities were involved together with the Royal Aircraft Establishment at Farnborough. The Universities were Bristol, Leicester, Birmingham and University College. The contributions of experiments were:

—Cosmic-ray Detector—Bristol University.

—Two X-ray Experiments (Astronomical)—Leicester and Birmingham jointly with the Mullard Space Science Laboratory of University College.

—Two Technology Experiments—RAE Farnborough.

Very substantial scientific results have been achieved. The Bristol University cosmic-ray equipment has provided, for the first time in a single exposure, observations of the ultra-heavy cosmic-ray particles throughout the entire range of the elements from Iron to Uranium. A number of surprising features have been brought to light in consequence. To name one, it was found that there is a striking OVERABUNDANCE of elements with charges between 58 and 72. This implies that there is an overabundance of ultra-heavy particles in the cosmic-ray source regions. When taken together with the abundances over the whole of the remaining charge range this will enable a greater understanding of the mechanism of cosmic-ray production and the acceleration.

The X-ray experiments have also been extremely successful. In the Leicester Experiment which was designed primarily to follow up the results of observations by Ariel V 30 X-ray sources have been studied in great detail. Special note here is due to the very effective spectral and variability data for several of the Black Hole candidates and a determination of the rotation periods of a number of accreting Neutron Stars. The examination of several quasars and Sefert galaxies has revealed the presence of strong Iron emission. This leads to the conclusion that there is an abundance of the heavy elements in the gas surrounding the nucleus. Also the emission spectra in the nuclear regions show very high temperatures. Simultaneous optical and X-ray observations have been carried out.

The low-energy X-ray telescope provided by Birmingham University and University College London was designed to explore a relatively new region of the spectrum. Results here include a study of twenty sources in detail. One of these was Cygnus X2. This has been shown to contain a White Dwarf star: an unexpected result since Neutron Stars are usually involved in the production of X-ray stars in binary systems or in star pairs.

Line emission has been detected during a stellar flare in Ursa Major (the Great Bear). This will be an opportunity to permit examination of the gas heating process. In addition to all this, a major study of diffuse X-ray emission from the sky was made.

With the success however there were problems. One example was spurious switching, which was thought to be from ground based sources, of the sub-systems such as high voltage supplies and the on-board recorders; large scale temperature excursions during periods of full sunlight; a slow degradation of the battery voltage with protracted recovery times and anomalies in the on-board sensing system producing significant errors in pointing. However, in spite of these difficulties Ariel VI was kept in operation by the concentrated effort of all those concerned. One of the major means of keeping up the flow of data was by means of a portable ground station set up by University College at a site near Canberra, Australia, and a ground station at the Italian San Marco Station in Kenya. By these means the satellite has twice been able to extend operations beyond the original 2 year design.

The satellite was launched on a NASA scout vehicle from the Wallops Island complex at Virginia, USA. The contract for the design and development of the satellite was carried out by Marconi Space and Defence Systems, Portsmouth and the manufacture of the satellite structure and mechanism sub contracted to British Aerospace at Bristol.

INTELSAT 6

Negotiations are going on between International Telecommunications Satellite Organisation and Hughes Space and Communications Space Group for the construction of a series of Intelsat communications satellites.

The design submitted would cost about 1 million dollars for each vehicle. The dimensions are 11·8 feet in diameter and 37 to 38 feet in height with a weight of the order of 7,700lbs.

LUNAR ORBITING LABORATORY

The European Space Agency has revived the studies for a Lunar Orbiting Observatory in place of the United States-European cooperation Moon project which had to be abandoned because of US fiscal problems. Europe had already seriously discussed the move to 'go it alone'. A number of concepts are being considered for an all European, Moon observation project.

One proposal for the mission calls for the Max Planck Institut and AMSAT the Amateur Satellite Corporation, to develop a lunar relay satellite under German Government funding. The relay craft would provide tracking/relay functions when the mission's primary orbiter vehicle is over the far side of the Moon. The original Polo mission plan was envisioned as a spin stabilised satellite to be placed in high orbit. The large primary orbiter would be three axis stabilised and would operate from a lower lunar orbit. Decisions will have to be made by the end of the year if it is to be in the 1980's programme.

DISCO MISSION

The European Space Agency's Disco mission would investigate the Sun's interior by measuring global oscillations in the visible spectrum and variations of the solar constant. The spacecraft would be launched by an Ariane launcher and flown to a place between the Earth and the Sun at the libration point. This is approximately 931,500 miles from the Earth on the Earth/Sun line.

stereo cassette deck part 2

ANOTHER SEPARATE FOR THE PE QUASAR STEREO SYSTEM

THE p.c.b. design and the component layout for the Quasar are shown in Figs. 1&2. Take care with the orientation of the semiconductors and the electrolytic capacitors. After soldering recheck all the components have been correctly placed and remove any solder splashes from the copper side of the board.

The holes for the two wooden battens should be drilled and countersunk as shown in Fig. 3, alternatively if the correct adhesive is used screws will not be required.

Before fitting any components to the front panel temporarily fit the fascia panel legend to the front panel and using the front panel as a template cut the mounting holes in the legend using a sharp knife. Carefully remove the legend and fit the slider potentiometers and the two slider switches. Note the earth tag on the GNR switch.

The VU meter should be glued into position taking care that it is correctly orientated. The legend can now be fitted to the fascia panel using either glue or double sided tape. Once the legend has been fitted mount the combined recording bias and on/off switch (S4).

CASSETTE DECK

There are four mounting brackets to be fitted to the cassette deck as shown in Fig. 3. Take special care that the screw shown arrowed in the photograph is shorter than the others or the pause key will not operate correctly. The record/play switch (S1) should be fitted to the cassette deck using the bracket shown in the photograph opposite. Note the switch pins should be trimmed and then mounted with the cut pins nearest to the mechanism.

The two aluminium brackets should now be fitted onto the cassette compartment and the control keys also fitted with the record key fitted on far left.

The case should be drilled and SK1 and the two jack sockets (JK1) fitted. Also fit the fuse holder, C48, the tag strip and T1. Please note that the mains transformer must be placed as shown otherwise 'hum induction' will occur. If a different layout is used and space is limited a toroidal transformer must be used (18V sec. @ 0·5A).

Two pieces of tin foil are used on the front and side panels for screening purposes and these should be glued into position after the holes have been drilled. The front panel can now be inserted into the case and the case glued.

WIRING

The top of the cassette deck should be wired before it is installed into the case and the wiring clipped as shown. The mechanism can then be screwed into position and the cables from the heads marked and routed through to the p.c.b. The p.c.b. should be wired first and then the components fitted to the pots and switches. After the unit has been wired recheck all the connections against the wiring diagram. The VU meter can be illuminated by connecting a 24V bulb across the secondary of the transformer and mounting it behind the meter.

When all the wiring has been checked the p.c.b. should be mounted under the cassette mechanism on the four pillars. The earthing method should not be changed from that shown in Fig. 3 otherwise 'hum loops' or 'hum pick up' will occur.

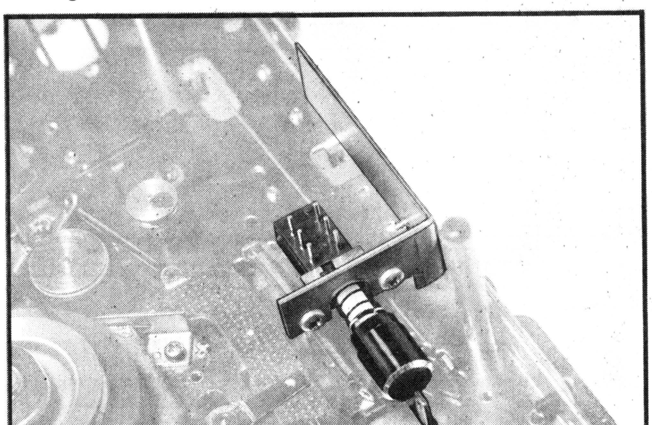
The backplate should also be fitted with tin foil and then connected to the earth tag on the transformer T1.

TESTING

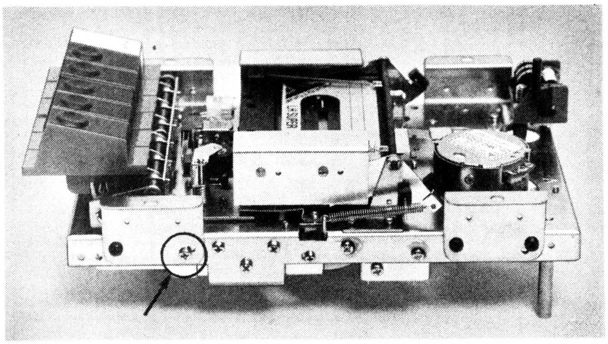
Initially set the presets to the positions shown in Fig. 2 and then switch on the unit and measure the supply voltage on the p.c.b. The on/off switch is a push-pull type and the up position is on.

PLAY

With the GNR switch in the off position insert a pre-recorded tape and switch on the power. When the play key is depressed the system should be functional, if not switch off immediately and recheck the wiring. Assuming everything is OK then check the fast forward, rewind, pause and auto stop. With all the keys in the off position observe the signal to noise level and then turn the GNR switch to the



Mounting details of the record/play switch S1



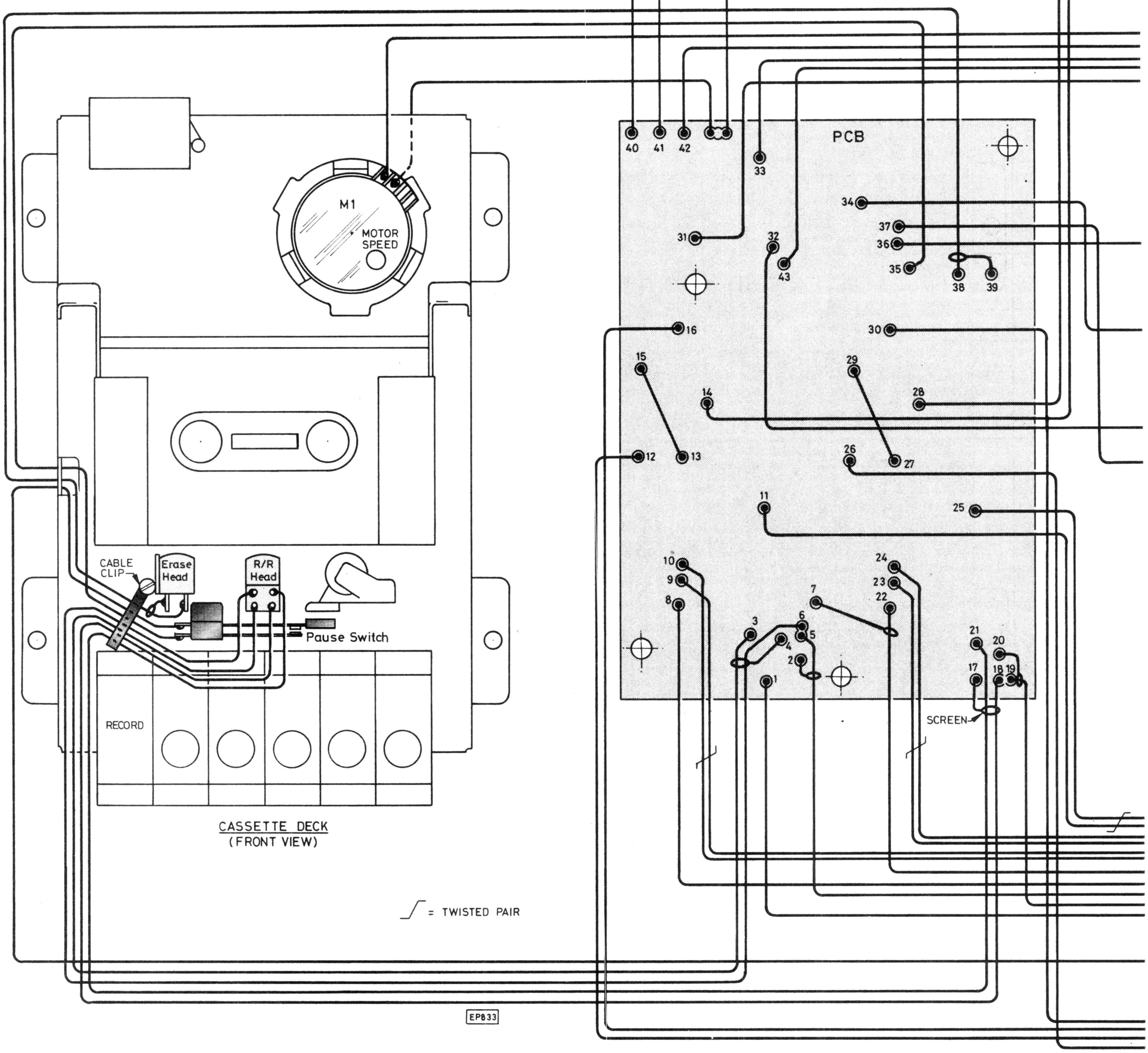
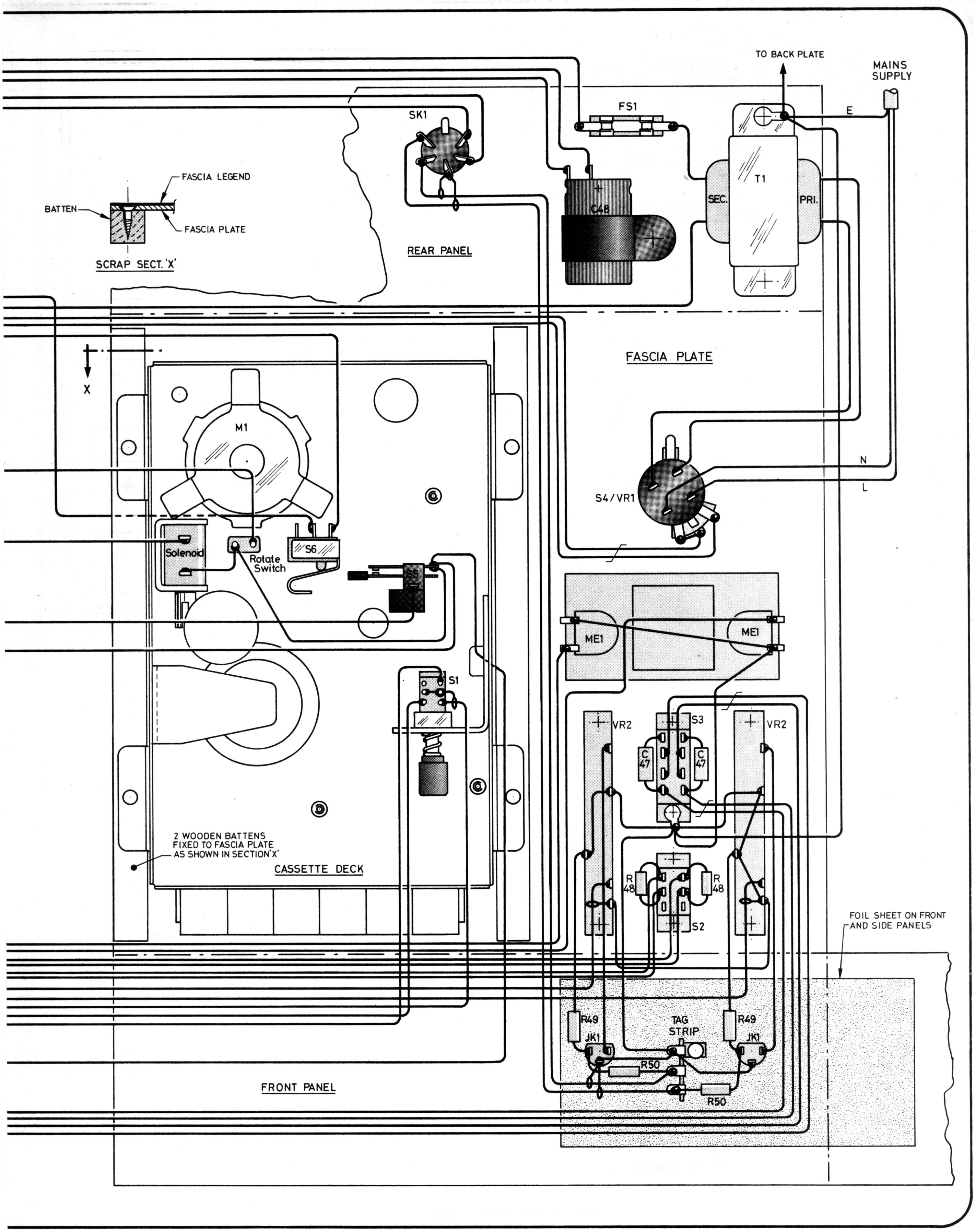


Fig. 3. Wiring diagram for the Quasar. Note the arrowed screw in the photograph should be shorter than the other bracket screws


TO BACK PLATE
MAINS SUPPLY
E
FS1
SK1
T1
SEC.
PRI.
C48
FASCIA LEGEND
BATTEN
FASCIA PLATE
SCRAP SECT. 'X'
REAR PANEL
FASCIA PLATE
X
M1
N
L
S4/VR1
Solenoid
Rotate Switch
S6
S5
ME1
ME1
S1
VR2
S3
VR2
C 47
C 47
R 48
R 48
S2
2 WOODEN BATTENS FIXED TO FASCIA PLATE AS SHOWN IN SECTION 'X'
CASSETTE DECK
FOIL SHEET ON FRONT AND SIDE PANELS
R49
TAG STRIP
R49
JK1
JK1
R50
R50
FRONT PANEL

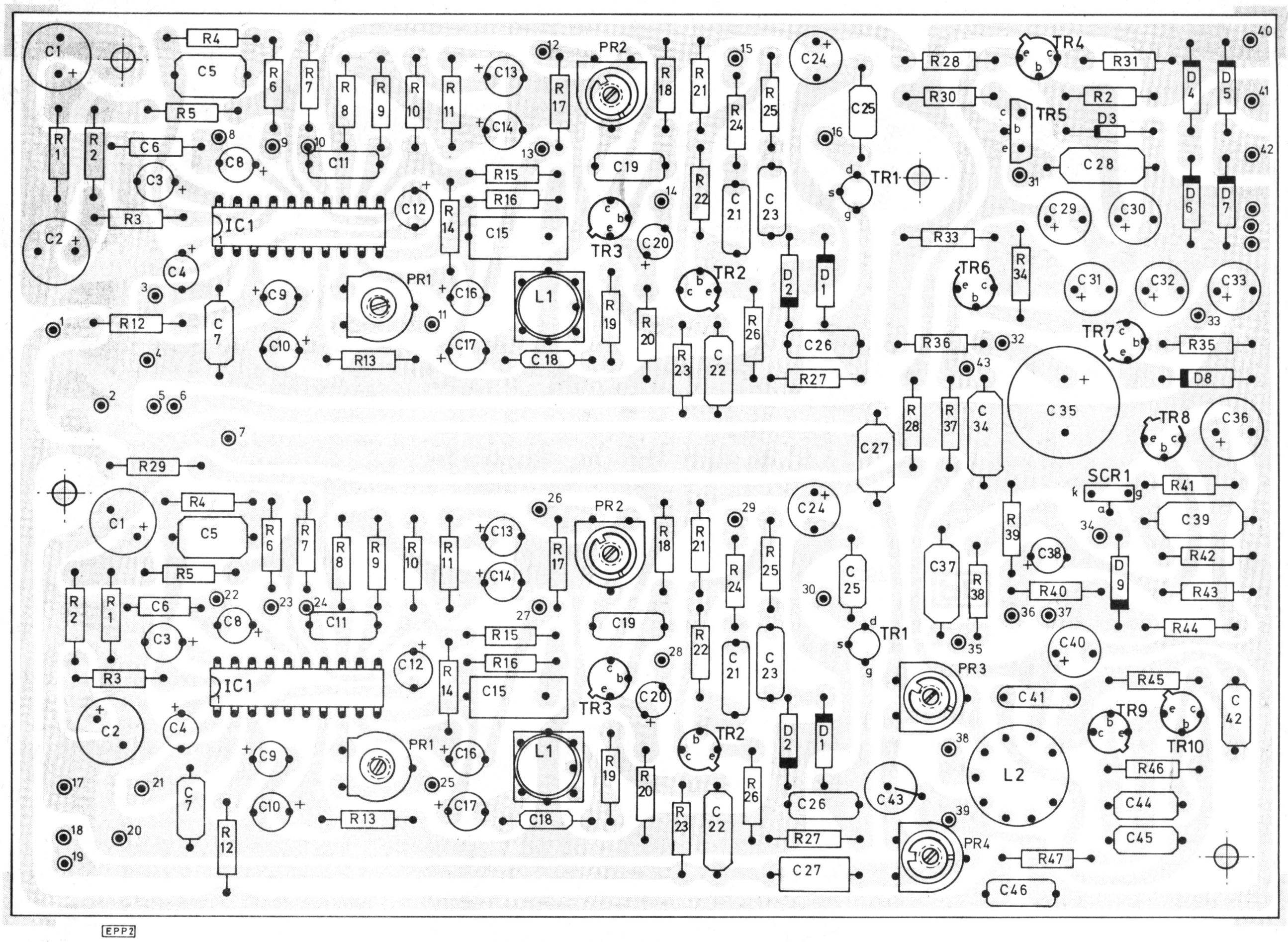


Fig. 2. Component layout

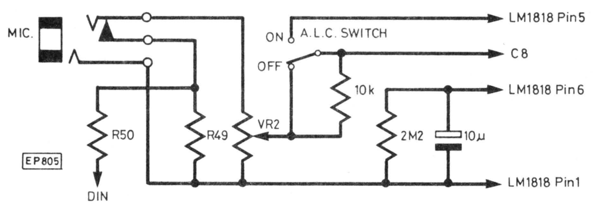


Fig. 4. Optional auto level control (ALC) switch circuit.

The ALC circuit is shown in Fig. 4. The level controls should be set to maximum during ALC recording. Screened wires (connected at one end) should be used.

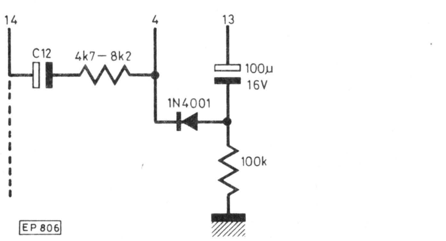


Fig. 5. Optional turn-on transient suppression for the meter/ALC circuit.

If additional meter suppression is required then the circuit shown in Fig. 5 can be used. The copper track between C12 and pin 4 should be cut and replaced with a 4k7 and 8k2 resistor. The other components can be "hung" between the pins. Note: Depending on the value of the resistors used the meter/ALC drive sensitivity will drop. PR1 will require resetting.

If a signal generator is not available then the settings for the preset shown in Fig. 2 should suffice. A more accurate alignment of PR1, PR3 and PR4 requires a scope and audio generator. The presets PR3 and PR4 should be set so that the pk-pk voltage across the head corresponds to the markings around VR1 (a scope with low input capacitance, typically 20pF, should be used to obtain the correct level). The two meters are calibrated via the presets PR1 and with the tape set in the record mode feed a 30mV sine wave signal @ 1kH into the DIN input. With the level controls at maximum adjust the presets to 0dB (the beginning of the red line on the meter).

The head wires and the record/play switch wires near the p.c.b. can be adjusted to cancel any 'hum' present.

If the DIN input/output socket is connected to an amplifier and the amplifier has no facility for switching off the 'tape output signal' positive feedback may result when the tape output signal level is high i.e. the signal from the tape recorder is amplified by the amplifier and feeds back into the input of the cassette. If this occurs set the level control to minimum during playback.

Should meter reading on record be encountered when there is no input signal check the screening is correct and the adjustment of L1. If the meter still shows a deflection fit a small screen over the top of the record/play switch. ★

MICRO-BUS

Compiled by DJD.

Appearing every two months, Micro-Bus presents ideas, applications, and programs for the most popular microprocessors; ones that you are unlikely to find in the manufacturers' data. The most original ideas often come from readers working on their own systems; payment will be made for any contribution featured.

THIS MONTH'S Micro-Bus is dedicated to all the overseas readers of the column, and includes contributions for the ZX80 and ZX81 microcomputers from Iceland, Portugal, Sweden, and Hungary.

KEYBOARD CLICK

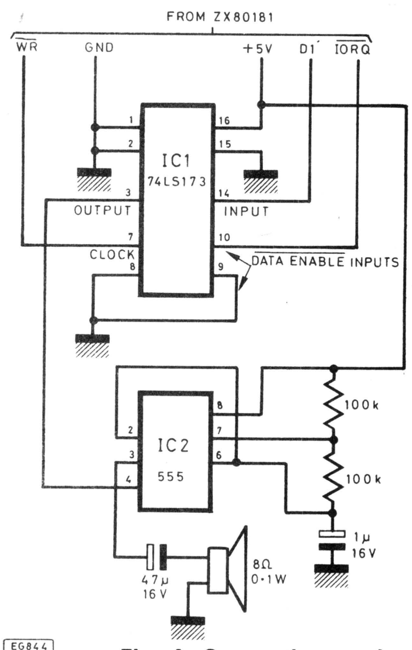
An ingenious circuit devised by *Peter Gudjonsson* of Iceland for the ZX80 or ZX81 eliminates the need to look at the screen when entering programs. It gives positive feedback in the form of an audible click every time a key is pressed. The circuit, shown in Fig. 1, uses a 74LS173 tri-state register to gate the keyboard strobe, line D1', into the gate input of a 555 timer. The components will fit onto a small stripboard which can be connected to the ZX81 via the backplane: see Fig. 11.

INVERSE VIDEO

The normal ZX81 display mode is black text against a white screen. However, *Antonio Joao Gomes Nunes* of Portugal has discovered a simple way of inverting the picture for people who prefer white characters on a black screen; see Fig. 2. In the circuit, shown in Fig. 3, the first inverter inverts the video signal, but since it also inverts the TV sync. signals it is necessary to reconstitute them using the other two inverters and R1.

The circuit is connected between the video output of the computer and the UHF modulator, and to do this it is necessary to cut the UHF video input terminal (the one nearest the jack sockets; see Fig. 4). The circuit power supply can be obtained from the 0V and 5V connections on the backplane: see Fig. 11.

Fig. 1. Circuit produces a keypress click on the ZX80 or ZX81



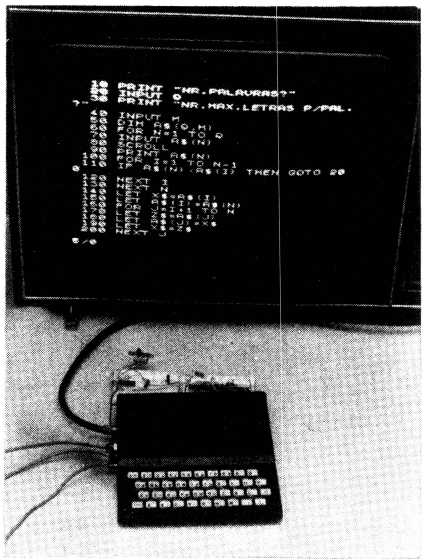


Fig. 2. ZX81 display produced by Inverse Video circuit of Fig. 3.

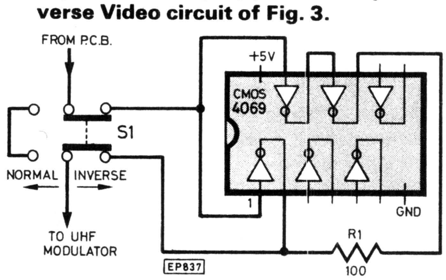


Fig. 3. Circuit inverts the display of a ZX81 to give white text on a black screen

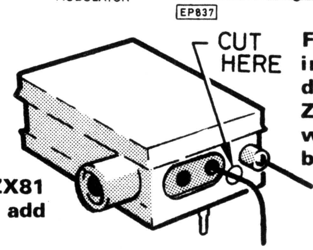


Fig. 4. Connection to the ZX81 modulator should be cut to add the Inverse Video circuit

ZX81 RENUMBER

A renumber program for the ZX80 was featured in last *November's* Micro-Bus. The following program, also submitted by Antonio Joao Gomes Nunes, performs the same function on the ZX81, though in a totally different manner. It finds the bytes containing the line number by PEEKing the bytes containing the length of the previous line, giving a faster and shorter program.

To use the program, first enter the program to be renumbered, and not all lines containing GOTO statements. Before entering the Renumber program perform the following direct command:

LET Z=PEEK 16396 + 256 *PEEK 16397 − 1

This sets Z to the address of the last byte in the program memory, for use in the renumber program. Now type in the program, shown in Fig. 5, and execute it by typing GOTO 9000. When the listing reappears amend all the previously noted references to line numbers in GOTO statements, and delete the Renumber routine.

The program works as follows: In lines 9400 and 9600 the pointer N is pointed to the next byte containing a line number by adding its value plus 3 to the PEEKed length of the line; it is then incremented in line 9600. The new line number L is POKEd into bytes N and N+1 by lines 9200 and 9300. As shown the program renumbers starting with line 10 and with increments of 10, but this can be changed by altering lines 9000 and 9500.

```
9000 LET L=10
9100 FOR N=16509 TO Z
9200 POKE N,INT(L/256)
9300 POKE N+1,L-INT(L/256)*256
9400 LET N=N+3+PEEK(N+2)+256*PEEK(N+
9500 LET L=L+10
9600 NEXT N
9700 LIST
```

Fig. 5. Renumber routine for the ZX81

REACTION TIMER

The reaction-timer program of Fig. 6 was developed by *Silvestre Carmeiro* of Portugal to measure reflexes on his ZX81. The reaction time is obtained over a number of attempts, specified on first running the progra a black bar appears in the centre of the screen the "P" key is pressed as quickly as possible, and the reaction time, in hundreths of seconds, is displayed on the screen. Pressing the "A" key then repeats the test. After all the tries are

completed the computer will print the average reaction time.

Lines 80 and 90 make the black bar appear after an unpredictable time (between about 0·1 and 15 seconds); the "*" characters in line 100 represent inverted spaces. Lines 110 to 140 form a clock to count the reaction time. If the "P" key is held down before the bar appears the program claims that cheating has occurred, and a reaction time of 4 seconds is added to the running total!

```
 10 REM REFLEXES
 20 RAND
 30 PRINT "NUMBER OF TRIES?"
 40 INPUT N
 50 CLS
 60 LET Y=0
 70 LET Z=0
 80 LET A=20*RND
 90 IF INT A<>4 THEN GOTO 80
100 PRINT AT 10,14 "***"
110 POKE 16436,255
120 LET A$=INKEY$
130 IF A$<>"P" THEN GOTO 120
140 LET X=253-PEEK 16436
150 CLS
160 IF X<=4 THEN PRINT "YOU ARE CHEATING"
170 IF X<=4 THEN LET X=200
180 PRINT X*2
190 LET Y=Y+X
200 LET Z=Z+1
210 IF Z=N THEN GOTO 280
220 PRINT
230 PRINT "READY?"
240 LET B$=INKEY$
250 IF B$<>"A" THEN GOTO 240
260 CLS
270 GOTO 80
280 CLS
290 PRINT "MEAN REACTION TIME"
300 PRINT
310 PRINT INT(0.5+(Y/Z*2));" HUNDREDTHS"
```

Fig. 6. Reaction timer program for the 1K ZX81 measures reflexes over a number of attempts

ETCH-A-SKETCH

An Etch-a-Sketch program was featured in the January 1981 Micro-Bus. The version for the ZX81 shown in Fig. 7, devised by Anders Ljungfeldt of Sweden, not only allows diagonal movement, but also occupies less memory, thus allowing a larger drawing-board.

To start drawing press the "S" key, and the pixel at (35, 35) will appear on the screen. This is the top-right limit of the drawing board. The keys Q, W, E, A, D, Z, X, and C are used to draw up, down, right, left, or diagonally, according to the position of the key. The central key, "S", is used to shift between drawing and erasing.

```
 10 LET A=35
 20 LET B=35
 30 LET U=1
 100 PAUSE 400
 110 POKE 16437,255
 120 LET X$=INKEY$
 200 IF X$="Z" OR X$="Q" OR X$="
A" THEN LET A=ABS(A-1)
 210 IF X$="E" OR X$="D" OR X$="
C" THEN LET A=A+1
 220 IF X$="Z" OR X$="X" OR X$="
C" THEN LET B=ABS(B-1)
 230 IF X$="Q" OR X$="W" OR X$="
C" THEN LET B=B+1
 240 IF X$="S" THEN LET U=U+1
 250 IF INT(U/2) <> U/2 THEN GOT
O 320
 260 IF A>35 THEN LET A=35
 270 IF B>35 THEN LET B=35
 300 PLOT A,B
 310 GOTO 100
 320 UNPLOT A,B
 330 GOTO 100
```

Fig. 7. Etch-a-Sketch for the ZX81 gives cursor drawing on the screen

ZX81 COMPOSES MUSIC

A recent letter to Micro-Bus included a cassette of a very catchy tune, apparently played on an electronic organ. The accompanying letter revealed that the tune had been improvised by a program running on a ZX81, which was linked to a synthesiser by a simple interface. The idea was developed by *A. A. Szalay* of Hungary, and the following description is based on his letter.

SYNTHESISER INTERFACE

The circuit shown in Fig. 8 will interface a ZX81 to a standard 1V/octave analogue synthesiser. With the program to be described it can be used as a sequencer, and many more interesting ideas are possible.

The circuit uses output ports 3, 7, and 11 on the ZX81, to avoid any conflict with those used by the computer. The 4013 acts as a monostable, producing a trigger pulse long enough for the synthesiser. An R-2R resistor ladder is used as a simple D/A converter, and R should be chosen as at least 500K ohms to match the output resistance of the CMOS latches. The resistors chosen for the ladder should be matched accurately, and the following easy method is recommended: Obtain a pack of about 40 resistors, measure them, and arrange them in order of magnitude (a simple program on the ZX81 could be used to do this): the result should be a Gaussian distribution of resistances. For the 5 single resistors of value R choose the 5 resistors from the middle of the distribution. Then for the 7 resistors of value 2R, connect in series 7 pairs taken in order from either side of the distribution. By this method a ladder with an accuracy of 0·1% can be achieved using standard 5% resistors.

The reisitor ladder drives a pair of op-amps, to produce a voltage output determined by the digital input. The CMOS i.c.s should be connected to the ZX81's 5V supply rail, but the supplies for the op-amps can be derived from batteries.

SEQUENCER PROGRAM

The following simple example shows how the interface can be used to control a synthesiser. First type into the ZX81:

10 REM 0000000
POKE 16514, 62 (LD A,N)
POKE 16516, 211 (OUT N,A)
POKE 16517, 3
POKE 16518, 201 (RET)

This stores machine code into the "0" characters in the REM statement. Now, suppose you have a series of notes whose pitches are X(N) and whose lengths are Y(N); these can be output in sequence by the operation:

100 POKE 16515, X(N)
110 LET A=USR 16514
120 PAUSE Y(N)
130 POKE 16437, 255

The time needed for the BASIC calculations is negligible, so there is no advantage in coding this section in machine code; however, the ZX81 should be run in fast mode.

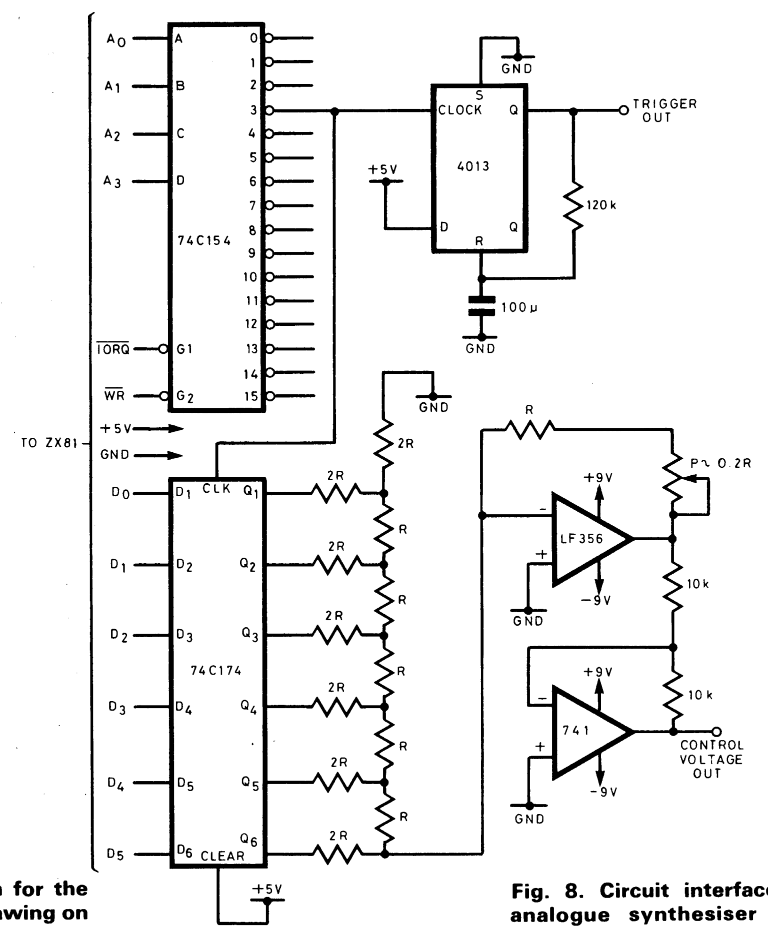


Fig. 8. Circuit interfaces an analogue synthesiser to a ZX81

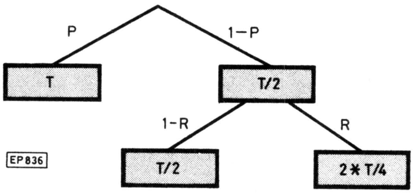
ROCK IMPROVISATION

As a complete demonstration of the use of the interface, the program of Fig. 9 improvises tunes in C minor, with 4/4 time. The program chooses random notes of the scale, and random intervals of T, T/2, or 2*T/4, subject to the following constraints:

1. The relative probability of the timings can be specified.
2. The time sequence always finishes at 4/4 periods.
3. In the case of 2*T/4 (a rapid scale passage) the pitches are not chosen at random, but as neighbours of the preceding ones.

In this case the time needed for the BASIC calculations is not negligible, but the timings are corrected to allow for it. The timing probabilities P and R can be seen from the scheme in Fig. 10; the values P=0·2 and R=0·2 are recommended.

Fig. 9. Scheme used for choosing the note durations in the rock improvisation




```
 15 PRINT "T:T/2"
 20 INPUT P
 25 PRINT "2*T/4:T/2"
 30 INPUT R
 40 LET U=0
 50 LET  E=INT(8*RND)
 60 POKE 16515,PEEK(16512+E)
 70 IF U=72 THEN GOTO 40
 80 LET A=USR 16514
 90 IF U=63 THEN GOTO 200
100 LET T=9*INT(RND+P)
110 LET U=U+T+9
120 IF T=0 AND INT(RND+R)=1 THE
N GOTO 400
125 FOR N=0 TO T/4.5
126 NEXT N
130 PAUSE 6+T
140 POKE 16437,255
150 GOTO 50
200 PAUSE 8
210 POKE 16437,255
220 GOTO 40
400 PAUSE 2
410 POKE 16437,255
420 POKE 16515,PEEK(16520+INT(3
*RND)+E)
430 LET A=USR 16514
440 PAUSE 3
450 POKE 16437,255
460 GOTO 50
```

Fig. 10. Program for the ZX81 controls a synthesiser to produce music improvisations

Before running the program the pitches of the allowed scale should be set up as follows: First add 9 more zeros to the REM statement in line 10, and then type in:

POKE 16520, 14 (D1)
POKE 16521, 12 (C1)
POKE 16522, 15 (E flat 1)
POKE 16523, 17 (F1)
POKE 16524, 18 (G flat 1)
POKE 16525, 19 (G1)
POKE 16526, 22 (B flat 1)
POKE 16527, 24 (C2)
POKE 16528, 27 (E flat 2)
POKE 16529, 26 (D2)

The program could be modified for use with other computers with sound output by replacing each **"POKE 16515, N"** statement by a statement which plays note N of the scale.

ZX81 BUS

Several readers have written in to ask for details of the ZX81 bus connections for use with circuits featured in Micro-Bus, since these are not supplied if the ZX81 is purchased assembled. Full details of the connections are therefore given in Fig. 11.

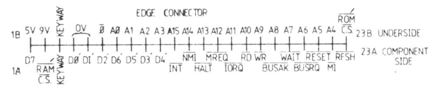


Fig. 11. Details of the ZX81 bus connections

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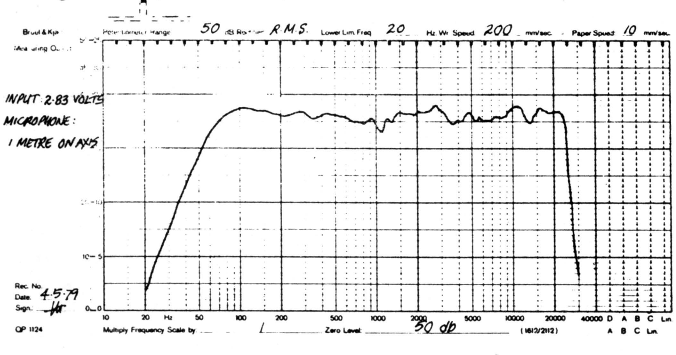

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ULTRASONIC VISION SYSTEM PART 2

Jeremy Bentham

ONCE the components have been assembled into the p.c.b. and checked, and the transducer has been connected as described last month, the motor can be connected. Five wires are needed to link the motor coils and the +ve common to their respective points on the p.c.b.: note that both +ve terminals on the motor must be connected to the common line.

TESTING

Do not connect the unit to the computer yet; first connect the p.c.b. to the supply, and monitor the supply current if possible. The unit should consume less than 30mA in the quiescent state, and there should be no signs of component overheating. If this is not the case, then switch off and recheck component orientation, soldering etc., paying particular attention to TR1, 5, 6, 7, 8 and their associated circuitry. The voltage across C3 should be checked: this should be around 5V, $\pm 0{\cdot}5$V.

Assuming all is well, power up the Atom, press the Break key, and plug in the ribbon cable. Ensure that the plug is the correct way round by tracing the wire from pin 1 of the p.c.b. (see component layout) to the bottom left-hand pin of the Atom printer port, as viewed from the back of the Atom. The supply current should now have risen to around 300mA. The reason for this is the Atom port is not initialised, and all its outputs are floating to a "high" state, switching on all the motor drive transistors. If REG 1 is fitted, it will warm up: if you are feeding it with eight volts or over, then a heatsink may be necessary.

To perform a quick test of the motor drive, execute the following command on the Atom:

?47107 = 127

This sets bits 0–6 of the port as outputs, and bit 7 as an input. The supply current should have returned to the quiescent value, since all output bits are set low. It should now be possible to step the motor. Execute the command

?47105 = 1

This energises coil 1 of the motor, the rotor should lock onto one position. Execute in turn

?47105 = 2
?47105 = 4
?47105 = 8

The transducer should have moved round in 7·5 degree steps, since you are energising each of the coils in turn. If you repeat the sequence, the motor should keep on stepping round. It is worthwhile checking that at each step the rotor is being firmly held: if not, check the circuitry associated with that coil. Now execute

?47105 = 0
?47105 = 64

The first command resets all outputs, the second one sets the transmit drive output, and should cause a single faint click in the transducer. Repeat these two instructions to check that a click can be heard.

If the unit is not responding to any of these commands, then check that the printer drive i.c.s have been correctly fitted within the Atom (IC1 and IC50). Try measuring the voltage on the pins of the port connector. Looking at the back of the Atom, the even pin numbers are at the top, and odd numbers at the bottom. When the initialisation command is entered, pins 3, 5, 7, 9, 11, 13, 15 should go low: when Break is pressed they should go high. All the even pin numbers should be at ground potential.

SOFTWARE

Once the unit is working, it is suggested that the program in Fig. 1 be keyed in and run. It requires 1K of graphics memory and text memory up to 3000 Hex. The objects seen by the unit are displayed on a single horizontal line, the distance away from the transducer being indicated by the distance from the left-hand margin. The transducer can be full-stepped by holding down the SHIFT or REPT keys. To make the program readily understandable, BASIC has been used for the plot routine. This makes the program run very slowly compared with the author's normal machine-code plotting, but it serves its purpose as a demonstration. Experiment with the setting of the sensitivity control, VR1. To stop the program, use the BREAK key, since this also resets the port. When using this or any other program, keep the transducer away from your TV set or monitor; many of these generate copious interference which will *lock up* the receive circuitry.

```
>LIST
   10 REM COMPVIS PROGRAM
   20 DIM LL(14)
   30 FOR I=0 TO 14;LL(I)=P;N.
   40 C=#B801
   50 U=#2F80
   60 FOR I=0 TO 1
   70 P=#2E00
   80[
   90¥
  100¥ TRANSMIT ROUTINE
  110:LL1 LDA @1;STA #AE;LDA C;AND @#F;TAY;ORA @#40;TAX
  120 LDA @10
  130:LL2 STX C;SEC;STY C;SBC @1;BNE LL2
  140 LDA @10
  150:LL3 STX C;SEC;STY C;SBC #AE;BNE LL3
  160 LDA @10
  170:LL4 STX C;SEC;STY C;NOP;SBC @1;BNE LL4
  180 LDA @10
  190:LL5 STX C;SEC;STY C;NOP;SBC #AE;BNE LL5
  200 LDA @10
  210:LL6 STX C;SEC;STY C;NOP;NOP;SBC @1;BNE LL6
  220¥
  230¥ RECEIVE ROUTINE
  240:LL7 LDX @0
  250:LL8 LDA C;STA U,X;LDY @30
  260:LL9 DEY;BNE LL9
  270 INX;BPL LL8;RTS
  280¥ .
  290¥ SHIFT ROUTINES
  300:LL10 LDA C;LSR A;AND @#F;BNE LL11;LDA @8
  310:LL11 STA C;RTS
  320¥
  330:LL12 LDA C;ASL A;AND @#F;BNE LL13;LDA @1
  340:LL13 STA C;RTS
  350]
  360 NEXT I
  370 REM
  380 REM INITIALISATION
  390 !#208=!#208+3
  400 ?#B80C=0;?#B803=#7F;?#B801=1
  410 CLEAR 1
  420 REM
  430 REM TRANSMIT-RECEIVE-PLOT
  440 LINK LL1
  450 FOR J=0 TO 127
  460 A=15;IF J?U<128 THEN A=13
  470 PLOT A,J,10
  480 NEXT J
  490 REM
  500 REM MOVEMENT REQUIRED?
  510 IF ?#B001 & #80 =0 THEN LINK LL10
  520 IF ?#B002 & #40 =0 THEN LINK LL12
  530 GOTO 440
  540 END
```

Fig. 1. Test Program. Note: The ¥ symbols should be replaced by backslashes

It is beyond the scope of this article to give details of the software used for the radar-type plots in the photographs. It is hoped to make this and other software available on cassette together with annotated listings. However, there follows a description of the test software, to assist those wishing to convert it to another machine or write their own. To those of you unfamiliar with the Atom, the software must appear very peculiar, since it contains a mix of BASIC and 6502 assembly language. In other machines it will be necessary to assemble the machine code separately, and then join it on to the Basic. Lines 20, 30, 60, 360 are used to manipulate the Atom assembler, and are not otherwise required. Lines 40, 50 set two variables for use by the assembler, and line 70 sets the start address for the assembled code. The assembly language section is delimited by the square brackets in lines 80, 350. The mnemonics are standard 6502, except that immediate addressing is indicated by @, and a hash sign indicates a hex number. Multiple mnemonics per line are permitted if separated by a semicolon, and line labels are indicated by :LL followed by a number.

The program can be split into five sections: initialisation, transmission, reception, plotting and movement.

INITIALISATION

The Atom printer port uses a 6522 Versatile Interface Adaptor, addressed at locations B800 to B80F hex. The important addresses are:

B80C control of mode and handshaking
B803 port A directional register
B801 port A input and output

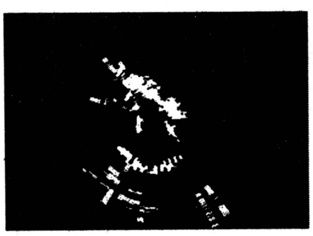
The vision system uses the following bits of port A:

Bits 0, 1, 2, 3 motor drive for coils 1, 2, 3, 4 (O/Ps)
Bit 6 transmit signal (O/P)
Bit 7 received signal (I/P)

When initialising the port for user I/O, it is necessary first to isolate it from the normal print drive routines, using the statement in line 390. Non-Atom users will no doubt be mystified by the use of the exclamation mark: it is being used to both PEEK and POKE a four-byte location! Line 400 sets the port to normal I/O without handshaking, sets bit 7 as an input and the rest as outputs, then turns on the driver for motor coil 1. Here, the question mark is used as a POKE command. The CLEAR 1 command in line 410 sets graphics mode 1 and clears the screen.

TRANSMISSION

Line 440 causes the BASIC program to execute the machine code at line 110, which is the transmit routine. This routine generates 10 cycles of each of the following frequencies: 66·7, 62·5, 58·8, 55·5, 52·6kHz. Since the frequencies are so high, it is necessary to use carefully-timed machine-code instructions. The routine needs one zero-page location; I have used AE hex, but any free location will do. Line 110 sets the X and Y registers with the port data: X has the transmit bit set, and Y has it reset. Each of the following pairs of lines generates one frequency, with a fixed 6 microsecond "on" pulse and the corresponding "off" time. Strictly speaking, the machine code should be located away from a page boundary, otherwise a page crossing will make one of the frequencies incorrect.



FULL STEPPING

	STEP NO.	1	2	3	4	
0	*					*INDICATES THE COIL IS ENERGISED IN THE STEP
▲	1		*			
CLOCKWISE	2			*		
MOVEMENT	3				*	
ANTICLOCK-WISE	4	*				
MOVEMENT	5		*			
▼	6			*		
	etc					

HALF STEPPING

	STEP NO.	COIL NO. 1	2	3	4
	0	*			
▲	½	*	*		
CLOCKWISE	1		*		
MOVEMENT	1½		*	*	
	2			*	
ANTICLOCK-	2½			*	*
WISE	3				*
MOVEMENT	3½	*			*
	4	*			
▼	4½	*	*		
	etc				

Fig. 2. Stepping motor control

RECEPTION

This machine-code routine follows straight on from the transmission, since any delay would result in data being lost. The X register is used as a pointer into a storage area from 2F80 to 3000 hex. Periodically, all 8 bits of the port are stored, and the pointer is incremented. In fact, bits 0 to 6 are being stored unnecessarily, since bit 7, the echo return, is the only one of interest. Line 260 serves to slow down the storage process, the amount of delay being set at the end of line 250. Changing the value from 30 will change the effective range that is stored and later plotted.

PLOTTING

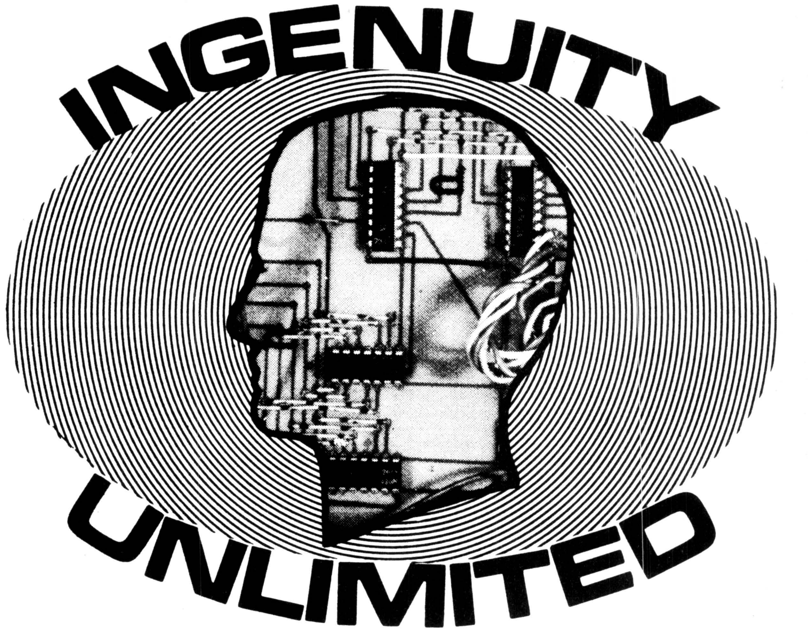
Lines 450 to 480 take the data just stored and plot it as a horizontal line. The line is composed of 128 separate points, so it is hardly surprising that the BASIC routine is slow. The question mark in line 460 is being used as an equivalent to PEEK (J+U). This is used to set A to 13 (to plot) or 15 (to unplot). It must be remembered that the output from the p.c.b. is normally high, and is held low in the presence of an echo.

MOVEMENT

Lines 510 and 520 detect whether the SHIFT or REPT keys have been pressed. If so, then the machine code to step the motor clockwise or anticlockwise is called. The sequence of signals to step the motor can be best understood by reference to Fig. 2. It should be noted that the motor is being full-stepped (7·5 deg. per step). If the signals were fed to the motor in the sequence described in the lower table, then each step would be half that value. Due to the tolerances in motor manufacture, the positional accuracy is worse when half-stepping, but it should be more than adequate for our needs, and there is no cumulative error.

DEVELOPMENT

Finally, if the reader comes up with any novel modifications, developments or applications for the Ultrasonic Vision System, then do write to P.E. All such ideas will be considered for publication. ★



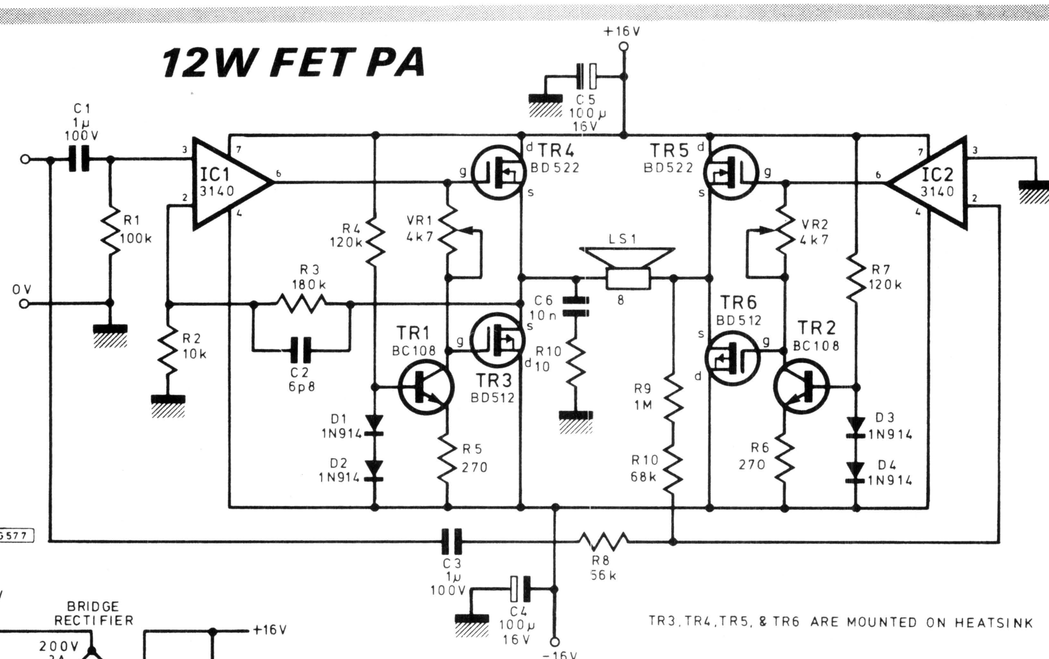
A selection of readers' original circuit ideas.

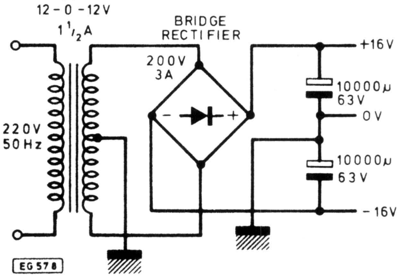
Why not submit *your* idea? Any idea published will be awarded payment according to its merits.

Each idea submitted must be accompanied by a declaration to the effect that it has been tried and tested, is the original work of the undersigned, and that it has not been offered or accepted for publication elsewhere. It should be emphasised that these designs have not been proven by us. They will at any rate stimulate further thought.

Articles submitted for publication should conform to the usual practices of this journal, e.g. with regard to abbreviations and circuit symbols. Diagrams should be on separate sheets, not inserted in the text.

12W FET PA





POWER FETs of the BD 512/522 series are relatively inefficient because of their large gate threshold voltage of some 2·5V and their high internal resistance. In a source follower mode the output voltage swing is only 65% of that on the gate for an 8 ohm load and typical transconductance. However, these problems can be overcome on low voltage power supplies if a bridge amplifier is used. The circuit shown is for such a high quality 12W r.m.s. amplifier using FET op-amps for ease of construction to drive the power FETs. The well-known CA 3140 is used because of its good slew rate and to obtain maximum output swing maximum voltages of plus and minus 16V are used.

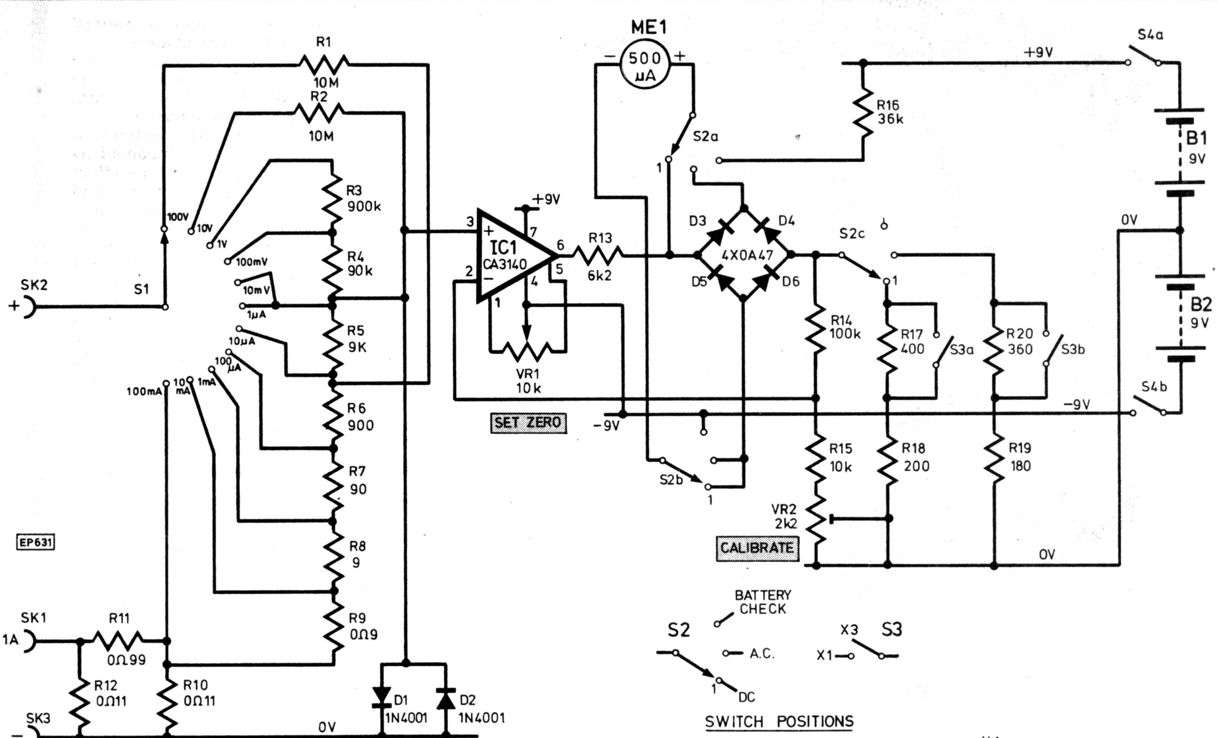
IC1 is used as a non-inverting amplifier with a gain of 19 and IC2 is similarly used but in the inverting mode. Input impedance is determined by R1 and R8 in parallel. TR1 (TR2 similarly) is a constant current sink of 1½ mA (the only concession to bipolars) and VR1 sets the bias of the power FET pair TR4 and TR3. VR2 sets the bias of TR5 and TR6 which are driven in opposite phase to TR4 and TR3.

The amplifier is capable of working to hundreds of kHz so C2 is used to reduce gain above 20kHz. An input of 500mV r.m.s. will produce a 12W output on an 8 ohm load. The bias is set at about 30 mA per pair of FETs using VR1 and VR2 each in turn and the total quiescent current will be about 80 mA.

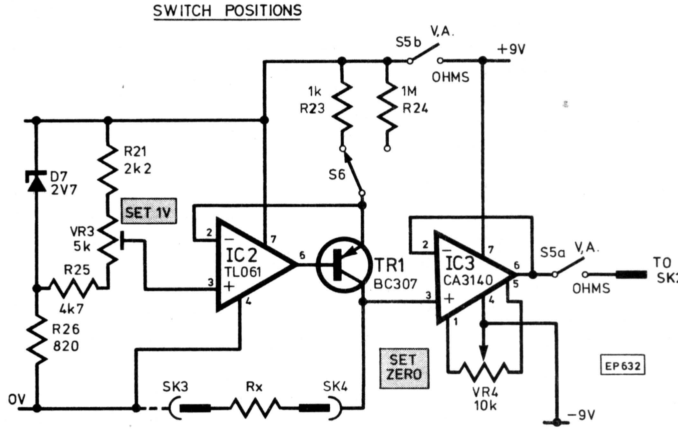
Good heat sinking is required for the four FETs. Note that the load is floating and is not earthed. The output is flat from 20 to 20000 Hz but is $-\frac{1}{2}$dB at these extremes. Distortion is low and noise is about −80 dB.

By bypassing C1 and C3 the amplifier responds to a d.c. input but quiescent offset voltage across the load caused by op-amp imbalance may have to be trimmed out.

R. Immelman,
Somerset West,
South Africa.



ELECTRONIC MULTIMETER



THIS multimeter design has an input impedance of 1MΩ/V or 333kΩ/V depending on whether one is reading in decade multiples of 1 or 3V/mV/A/mA/µA. The f.s.d. ranges are 10mV to 300V, 1µA to 3A a.c. or d.c. Protection is by D1, 2 and by R13.

An additional, optional ohmmeter circuit can be included although it was not built into the prototype to avoid circuit complication. However it has been very successfully used in conjunction with the prototype. Resistances from 10Ω (f.s.d.) to about 6MΩ can be measured on a linear scale.

The input voltage or current is converted by resistor chain R1–12 to a voltage at pin 3 of IC1 of up to 10 or 30mV. This voltage is amplified tenfold to 100/300mV. Resistors R17–20 convert this output to a meter current of up to 500µA. The meter rectifier section is arranged so as to make the germanium diodes' forward voltage drop immaterial and the 6k2 resistor limits meter current to 1·2mA, in case of overload. The d.c. range is connected so that wrong polarity inputs are not transmitted to the meter. The a.c. range has no capacitors and can be used as a null detector which always gives a positive meter deflection. Should d.c. level elimination be required, a capacitor can be put in the input test prods of value chosen to have low reactance.

Position 3 of S2 selects an independent battery check function. The meter reads full scale when the mean battery voltage is 9V.

The optional resistance measuring circuitry is a constant current source which sends 1mA or 1µA through a test resistor Rx connected to sockets SK3, 4. IC3 is a buffer stage which allows the 10mV to 10V d.c. voltage ranges to measure the p.d. across Rx without altering its value.

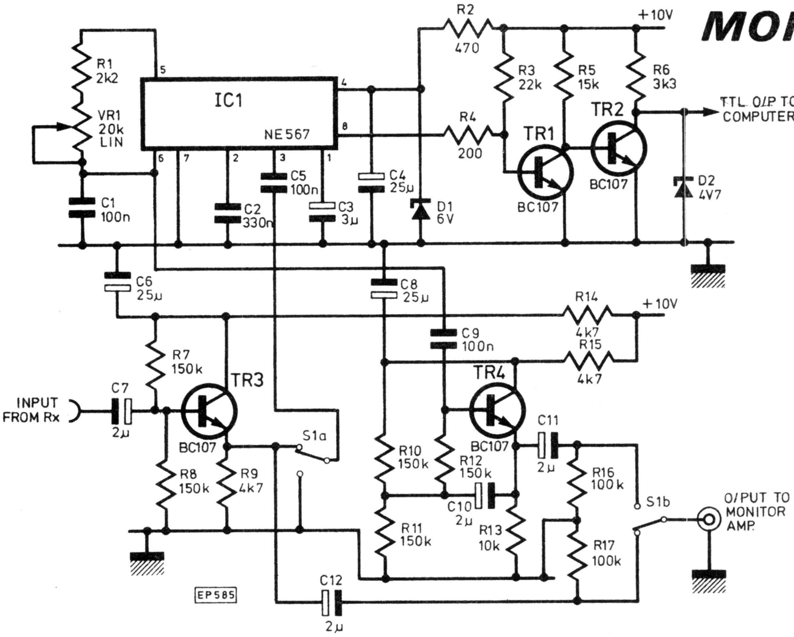
Resistors R3–7 are made by adding preferred values such as 15 and 75, or 43 and 47 in their decade multiples. They must be 2% types. R8 is 10Ω 2% and 91Ω 5% in parallel. R14, 18–20, 23, 24 are also 2%. R9–12 are made from constantan wire: 24 SWG is about 2·00Ω/m and 30 SWG is 6·29Ω/m. To standardise the wire accurately, a known current of about 10mA is passed through a sample and the rest of the multimeter (R8 connected to common line) used to measure the p.d./unit length. From this the resistance/unit length and hence required lengths are calculated.

R17 is a parallel combination of 470Ω 2% and 2k7 5%.

With the test prods from SK2, 3 shorted together, VR1 is adjusted for zero meter deflection. In the ohmmeter, VR3 is adjusted to set the test currents to 1mA and 1µA. With SK3, 4 shorted, VR4 is adjusted for zero output from IC3.

J. H. Greaves,
Ealing.

MORSE TONE DETECTOR



THE accompanying design has been used by the writer to detect the morse code tones found on the amateur bands. It takes its input from the audio output socket of a communications receiver or other radio, at line level, i.e. about 200mV peak to peak. It produces a single bit TTL compatible output, which can be fed directly into a computer port.

The circuit is based on the NE 567 phase-locked-loop (PLL) integrated circuit tone detector. The natural frequency of the oscillator on the chip is set by the time constant of VR1 and C1. If there is a tone present on the input, whose frequency is within ±10 per cent of the oscillator's natural frequency, then the output will go low. This capture range is set by the value of capacitor C2. C3 performs 'anti-bounce' decoupling on the output.

The manufacturers claim that the device will find a tone buried under six times its amplitude of noise. This means that virtually all humanly detectable morse tones are recoverable. The setting of VR1 is most easily performed by someone with a musical ear, in conjunction with switch S1. When switch S1 is pressed, S1a disconnects the receiver from the PLL, so that it runs at its natural frequency, and S1b connects the monitor audio amplifier to the PLL oscillator, so that a steady note, whose frequency depends on the setting of VR1, is heard. To tune into one particular tone, VR1 is simply adjusted to give the same pitched note when S1 is pressed, as is heard from the receiver when S1 is released.

The device has been found to work quite happily when two or more stations of equal loudness, but different tones, are transmitting simultaneously. The results have been beautifully punctuated weather reports and news items in many languages displayed on the computer VDU. Also, with a smaller value capacitor for C3, the device could possibly be used for receiving RTTY communications.

D. Greaves,
Crampmoor,
Romsey.

BANDPASS FILTER

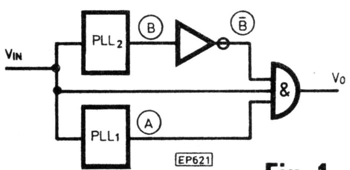


Fig. 1

IN Fig. 1 we can see the principle of this bandpass filter. There are two rectangles which have been marked PLL1 and PLL2 (PLL is a phase locked loop). The bandpass filter includes also NOT and AND ports. V_{in} is conducted to the PLLs and the AND port. This can be a squarewave or a sinewave. Its voltage must be sufficiently high that the AND port can go to a high state.

The circuit diagram of the complete bandpass filter is in Fig. 2. PLL1 is tuned with the preset pot VR1 to the lower limit frequency (cut off frequency f_L) of the band which we want to select. PLL2 is tuned with the preset pot VR2 to the higher limit frequency (cut off frequency f_H) of the same band.

I have selected from the circuit 4046 the part (the phase comparator) which doesn't lock to the harmonic frequencies of the base frequency but only to one base frequency.

The output of the PLL2 is inverted. Now we can get the high state outputs from both the PLLs over the band which we want to use.

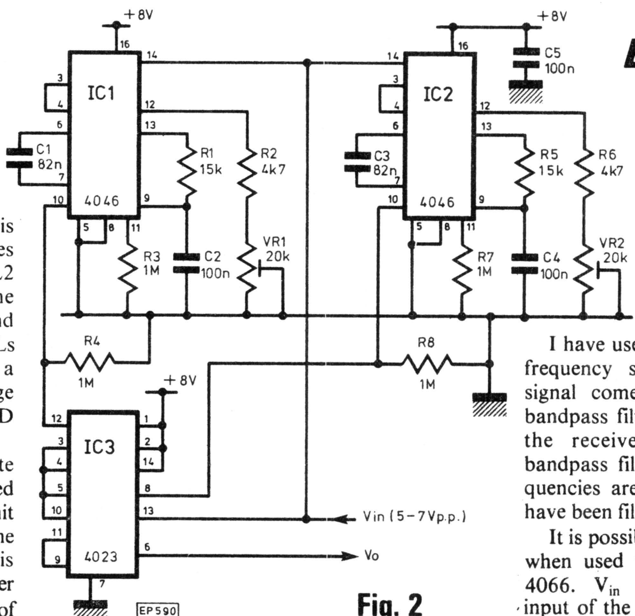


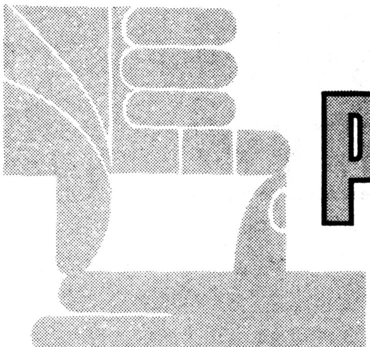
Fig. 2

The AND port works as a digital comparator. The squarewave signal comes out on the selected band but has the disadvantage that it has a fixed level about the supply voltage. The band can be selected on the wide range around 1kHz with the component values marked in the circuit. The bandwidth can be narrowed or widened as required.

I have used this bandpass filter before a frequency shift keying demodulator. A signal comes from the receiver to this bandpass filter. The sinewave signal from the receiver is triggered before the bandpass filter. The space and mark frequencies are 1070Hz and 1270Hz which have been filtered out.

It is possible to get out a sinewave signal when used with a switch e.g. a CMOS-4066. V_{in} must be conducted to the input of the switch instead of the input of the AND port and, of course, to the inputs of the PLLs. The output of the AND port drives the switch. From the output of the switch we can get the sinewave signal on the wanted band. A disadvantage is that the level of V_{in} must be inside the determined values.

Touko Valtamo,
Tampere,
Finland.



PATENTS REVIEW...

Copies of Patents can be obtained from:
the Patent Office Sales, St. Mary Cray, Orpington, Kent. Price £1·60 each.

DRIVING MUSIC

There's an interesting story, and a patent, behind the Record Runner' reported in Practical Electronics February 1982 (page 17). The Record Runner is a model VW van which drives round a record and plays it. It's covered by US patent 4 232 202 which was granted to Sony of Japan. The inventors Yoshihisa Mori, Norio Mashimo and Takeo Eguchi are all designers in the department of Sony which deals with hi fi record players and pickup cartridges. Yoshihisa Mori is not only an engineer, he's also a hi fi enthusiast and VW car enthusiast. Back in 1977 Mori built a toy VW minibus which ran round a disc and played it. That early prototype, which was briefly shown at the Paris Festival du Son and in Sony's showroom in Regent Street, was a primitive affair. It ran at constant linear speed and so tracked a record at progressively incorrect rotational speed. This is because the linear distance of a groove full turn varies from disc edge to disc centre. Subsequently Mori built a clever modification into his gramocar which

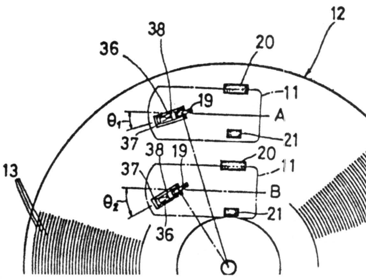


Fig. 1

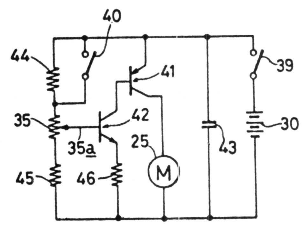


Fig. 2

enables it to change running speed automatically and continuously as it tracks in across the disc and so keep the playing speed constant at around $33\frac{1}{3}$rpm. This modification is described in US patent 4 232 202.

Sony decided against manufacturing and selling the gramocar under the Sony brand name. "We are a hi fi company, not a toy company" they told me last year. But now the car is on sale in Japanese shops under a different brand name and this is how it has found its way into Britain as an import.

The patent describes how the playing speed is kept constant. On board the car there is a small amplifier and loudspeaker and the pickup and stylus are mounted on an undercarriage. This is pivoted like a short gramophone tone arm, so as the car tracks in towards the centre of the disc the arm turns slightly around the pivot. This angular movement changes the value of the variable resistor which controls the motor speed to maintain a constant angular or rotational tracking velocity.

Figure 1 of the patent shows how the angle of the undercarriage and pickup changes as the car tracks in across the disc. Figure 2 shows the speed control circuit for a motor 25, which drives the car wheels. Angular movement of the undercarriage causes movement of the tap 35*a* of variable resistor 35 so that the base voltage applied to transistor 42 is decreased. This brings a corresponding decrease in the supply of current through transistor 41 to motor 25. So the motor drive speed, and thus the speed of the vehicle, progressively decreases as it moves towards the disc centre.

ENGRISH TLANSRATIONS

An assured growth area for the future is the automated translation of text and spoken language. Most of the major electronics firms, especially in Japan, already have research programmes underway. For the Japanese there is a special incentive to automate the translation of written text and spoken words. This is very clearly explained in recently granted British patent no 1 596 411, from the Kyodo News Service of Tokyo, Japan. The patent claims a computerised translation system intended primarily to speed up the transmission of telexes to and from Japan. The lengthy patent text, 37 pages of description and 34 pages of descriptive drawings, is too complex to discuss in detail. But essentially the Kyodo computer programme searches phonetically in a memory of phrases. In a first scan of the memory the computer hunts for a translation that exactly corresponds to a character train. If this scan fails, the last character of the train is dropped and the search made again. This continues, with the last character of the train being dropped each time, until there is an exact phonetic match between an index word stored in the computer memory and a character in the input train.

The patent is of more general interest because of its introduction. This explains the daunting task facing anyone who sets out to automate translation between the Japanese and English languages.

Most Japanese sentences are made up from five different kind of characters. *Kanji,* are Chinese picture characters representing phonetic expressions. *Hiragana* and *katakana* (generically called *kana*) are syllables characters representing components of words. Then there are Roman alphabetical characters, used where no equivalent Japanese character exists, and Arabian figures. There are tens of thousands of kanjis, although only 1850 are permitted for use in official documents. But 2,500 appear in newspapers and 5,000 are likely to be encountered in everyday life. There are 75 hiragana and katakana making a total of 150 kana. A recent survey showed that in Japanese expressions, 63% of the characters are kanji and 36% kana. Because of the difficulties in converting kanji and kana into International telex code, and converting Roman code into kanji and kana, any organisation involved in international communication usually translates before transmission. Kyodo estimates that it spends 30 billion Japanese yen a year on communication translations! It is a fact that most Japanese firms with subsidiary companies in the West simply give up and communicate both ways by telex in English. This is the background to patents on computerised translation such as BP 1 596 411. It is likely that over the next decade there will be many, many more.

In the February Patents Review', which dealt with a Texas Instruments patent, we mentioned that another Texas educational toy 'Speak and Maths' is available in America. Texas have informed us that 'Speak and Maths' is also available in this country.

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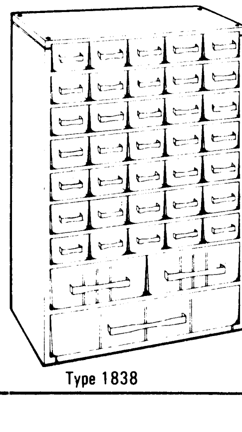

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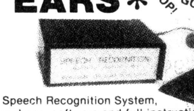

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40	5	10	**17.42**	1.84
120	6	12	**19.87**	2.04
121	8	16	**27.92**	O.A.
122	10	20	**32.51**	O.A.
189	12	24	**37.47**	O.A.

12 OR 24V OR 12-0-12V
Pri 220-240 volts

Ref	Amps 12V	Amps 24V	Price	P&P
111	0 5	0 25	**2·42**	0.95
213	1 0	0 5	**2·90**	1.00
71	2	1	**3·86**	1.00
18	4	2	**4·46**	1.20
85	0 5	2 5	**6·16**	1.20
70	6	3	**6·99**	1.20
108	8	4	**8·16**	1.44
72	10	5	**8·93**	1.60
116	12	6	**9·89**	1.60
17	16	8	**11·79**	1.72
115	20	10	**15.87**	1.84
187	30	15	**19.72**	2.04
226	60	30	**40.41**	O.A.

SCREENED MINIATURES

Ref	mA	Volts	£	P&P
238	200	3-0-3	**2·83**	0.50
212	1A, 1A	0-6, 0-6	**3·14**	1.00
13	100	9-0-9	**2·35**	0.50
235	330, 330	0-9, 0-9	**2·19**	0.60
207	500, 500	0-8-9, 0-8-9	**3·05**	0.95
208	1A, 1A	0-8-9, 0-8-9	**3·88**	1.20
236	200, 200	0-15, 0-15	**2·19**	0.60
214	300, 300	0-20, 0-20	**3·08**	1.00
221	700 (DC)	20-12-0-12-20	**3·75**	1.00
206	1A, 1A	0-15-20 (×2)	**5·09**	1.20
203	500, 500	0-15-27 (×2)	**4·39**	1.20
204	1A, 1A	0-15-27 (×2)	**6·84**	1.20
239	50	12-0-12	**2·88**	0.50
234	500	6-0-6	**2·19**	0·44

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Ref.	VA (Watts)	£	P&P
113*	15	**2.73**	1.00
64	80	**4.41**	1.20
4	150	**5.89**	1.20
53	350	**10.00**	1.44
67	500	**12.09**	1.84
84	1000	**20.64**	2.20
93	1500	**25.61**	O.A.
95	2000	**38.31**	O.A.
73	3000	**65.13**	O.A.
80	4000	**84.55**	O.A.
57	5000	**98.45**	O.A.

*0, 115, 220, 240.

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Ref			P & P
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172	1A	**3·26**	1.00
173	2A	**3·95**	1.00
174	3A	**4·13**	1.20
175	4A	**6·30**	1.20

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Amps 72v/96v	Amps 36v/48v	Ref.	Price	P&P
1	2	431	**8.12**	1.44
2	4	432	**13.35**	1.22
3	6	433	**16.17**	1.96
4	8	434	**20.65**	2.04
5	10	435	**29.30**	2.20
6	12	436	**36.69**	O.A.
8	16	437	**40.03**	O.A.

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Published approximately on the 15th of each month by IPC Magazines Ltd., Westover House, West Quay Road, Poole, Dorset BH15 1JG. Printed in England by Chapel River Press, Andover, Hants. Sole Agents for Australia and New Zealand – Gordon & Gotch (A/sia) Ltd.; South Africa – Central News Agency Ltd.
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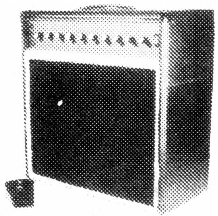

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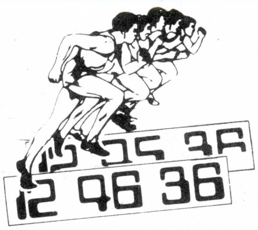

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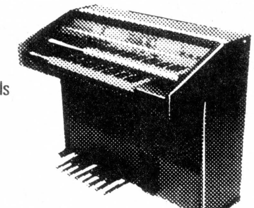

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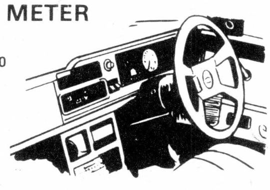

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